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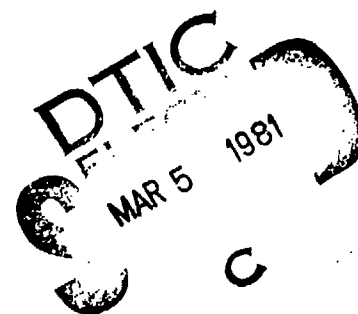
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MATERIAL DEVELOPMENT STUDY FOR A  
HAZARDOUS CHEMICAL PROTECTIVE CLOTHING OUTFIT

J.V. Friel  
M.J. McGoff  
S.J. Rodgers

MSA Research Corporation  
Evans City, PA 16033



August 1980

Final Report

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14. Abstract Expansion of a data base for protection of personnel engaged in handling accidentally discharged hazardous chemicals was the program objective. This involved assigning levels of protection, reviewing available protective equipment and material chemical compatibility, developing requirements and conducting a test program. A CHRIS listing of 985 chemicals reviewed showed 403 chemicals in the category that personnel be equipped with a sealed suit. Other categories assigned were nonsealed suit, fire suit, and in some instances only gloves and goggles for those chemicals which were innocuous. Literature review was used to establish a test plan. Test results showed that butyl rubber was 38% acceptable and polycarbonate 60% acceptable relative to 403 chemicals. There were 45 chemicals in which levels of protection were not assigned. These were placed into the category of future R&D. Other future R&D studies resulted from chemicals which could not be adequately decontaminated by a detergent-cold water wash in addition to those chemicals found incompatible with butyl rubber and polycarbonate.			
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# METRIC CONVERSION FACTORS

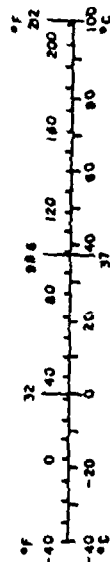
## Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
<b>AREA</b>				
sq in	square inches	6.5	square centimeters	cm <sup>2</sup>
sq ft	square feet	0.09	square meters	m <sup>2</sup>
sq yd	square yards	0.8	square meters	m <sup>2</sup>
sq mi	square miles	2.6	square kilometers	km <sup>2</sup>
acres	acres	0.4	hectares	ha
<b>MASS (weight)</b>				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
<b>VOLUME</b>				
teaspoon	teaspoons	5	milliliters	ml
tablespoon	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
cu ft	cubic feet	0.03	cubic meters	m <sup>3</sup>
cu yd	cubic yards	0.76	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

\* 1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.75, SO Catalog No. C13.10-286.

## Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
<b>LENGTH</b>				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	miles	mi
		0.6	miles	mi
<b>AREA</b>				
cm <sup>2</sup>	square centimeters	0.16	square inches	sq in
m <sup>2</sup>	square meters	1.2	square yards	sq yd
km <sup>2</sup>	square kilometers	0.4	square miles	sq mi
ha	hectares (10,000 m <sup>2</sup> )	2.5	acres	acres
<b>MASS (weight)</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	short tons
<b>VOLUME</b>				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
m <sup>3</sup>	cubic meters	0.26	gallons	gal
m <sup>3</sup>	cubic meters	36	cubic feet	cu ft
		1.3	cubic yards	cu yd
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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## EXECUTIVE SUMMARY

The U.S. Coast Guard has a mandate to respond to discharges of hazardous chemicals into or near the waters of the United States. Appropriate protective gear is required for the Strike Team personnel in order to cope with the toxicity and other hazardous properties of these discharges.

The Chemical Hazards Response Information System Manual (CHRIS) lists 985 chemicals which might be discharged into inland or coastal waterways. The manual provides the On-Scene Coordinator or other officials with some of the information necessary to properly respond to discharges of hazardous chemicals. The primary objectives of this program were to determine the levels of protection required for each of the chemicals and to develop guidelines for the personal protective equipment which might be required for Strike Team personnel.

It was obvious, at the inception of the program, that levels of protection could not be assigned for many of the chemicals due to lack of toxicological information. Further, it was determined that compatibility data for materials commonly used in protective ensembles, specifically butyl rubber and polycarbonate, did not exist.

Levels of protection were established by reviewing each of the 985 chemicals on the CHRIS list, referring to current information. Clothing requirements and respiratory protection were determined for each case where possible. Many of these required judgments based on good practice, chemical toxicity, expected exposure conditions, etc. Toxicity data was not available for 45 chemicals. For these, a level of protection was not established and they were placed into a future R&D category.

Protective clothing ensembles are available commercially, and the Coast Guard has acquired a Hazardous Chemical Protective Clothing Outfit (HCPCO). However, the levels of protection required for specific chemicals given in the CHRIS list have not been addressed in a correlated fashion. The ideal material which is totally compatible with all of the chemicals is not available - none of the materials used in manufacture of protective equipment has such compatibility. Requirements for use of a fully sealed

suit include: maximum wear time of two hours; 20 hours resistance to chemical damage (represents 10 wear cycles and decontamination); 10 year shelf life; ambient temperature of -30°C to 40°C; no UV or ozone degradation; be impermeable to 100% chemical contact. Materials of suit construction should also be relatively inexpensive and easy to fabricate. Decontamination should not degrade future performance.

Studies of information on suit materials compatibility of the 985 chemicals on the CHRIS list were confined to butyl rubber and polycarbonate, since these are the materials in the existing HCPCO ensemble. Of these chemicals, 403 were considered to require a fully sealed suit: 45 chemicals showed insufficient data for a decision and 15 chemicals are pyrophoric. Of the 403 chemicals requiring a sealed suit, it was found that sufficient data was not available on 113 chemicals for the polycarbonate chemical resistance, and 377 for the butyl rubber.

A materials compatibility program to demonstrate physical damage and penetration of materials by chemicals in question was performed. Decontamination effectiveness and degradation of protection by repeated decontamination were studied. In these tests, any detectable permeation of the test chemical through the butyl rubber on a continuous 20 hour penetration test was cause for failure. Additionally, failure during 10 contamination/decontamination cycles was cause for rejection. Seams were also studied and found to be difficult to decontaminate, but were basically as resistant as the parent butyl suit material.

As a result of this program and the best information available in the literature, polycarbonate was found to be compatible with 241 chemicals and incompatible with 119 chemicals; no assignment could be made for the remaining 43 chemicals. Butyl rubber was found to be compatible with 155 chemicals and incompatible with 187 chemicals; no assignment could be made for the remaining 61 chemicals.

# FINAL REPORT

on

## MATERIAL DEVELOPMENT STUDY FOR A HAZARDOUS CHEMICAL PROTECTIVE CLOTHING OUTFIT

### 1.0 INTRODUCTION

This report summarizes a study performed for the U.S. Coast Guard to broaden the data base on protective clothing required for Strike Team personnel. These personnel must deal with accidental discharges of hazardous chemicals into or near waters of the United States and various degrees of protection must be provided depending upon the specific chemical spill.

Work centered around the evaluation of butyl rubber and polycarbonate materials used in the Hazardous Chemical Protective Clothing Outfit (HCPCO), a sealed suit ensemble. Although some chemical compatibility data for butyl rubber and polycarbonate exists in the literature, data is limited on 985 chemicals of concern in regard to chemical compatibility and the degree of protection afforded. Chemical compatibility data in the literature applied primarily to engineering systems information, e.g., gasketing material, O-rings and so on, and translating it in the context of personnel protection is a different matter. This is because data on permeation and ability to decontaminate are even less known.

The project proceeded by completing succeeding task assignments. These were as follows:

Task I - Levels of Protection. The objective of this task was to provide information on the type of personnel protection that will be necessary for each of the 985 hazardous chemicals in CHRIS. Potential sources for personnel protection outfits were to be provided. The output of this task provided input into Task V (Material Compatibility Testing) and Task VI (Future R&D Effort). An Interim Report was prepared on Task I results.

Task II - Define Requirements. The objective of this task was to establish parameters which must be met for candidate materials so that they are suitable for use in a hazardous personnel protective outfit. Part of the task was to provide candidate materials and selection rationale. This task served as a basis for evaluation of candidate materials and, in this respect, was supplementary to the development of the test program plan.

Task III - Testing Program. The objective of this task was to devise a test plan based upon information generated in Tasks I

and II. Task V, Material Compatibility of Testing, was conducted according to the Task III test program plan.

Task IV - Interim Report. This task summarized the results of Task II (Define Requirements) and Task III (Testing Program). Approval of the Task IV Interim Report was required before proceeding with Task V, Material Compatibility Testing.

Task V - Material Compatibility Testing. The preceding task provided the guidelines for conducting Task V. The objective of Task V was to collect quantitative data on chemical resistance of butyl rubber and polycarbonate used in the HCPCO suit. Output of this task is factored into Task VI, Future R&D Efforts.

Task VI - Future R&D Efforts. The objective of this task is to recommend alternatives to butyl rubber and polycarbonate used in the HCPCO which do not provide suitable protection with some chemicals. Additional studies needed to further define levels of protection and to recommend protective garments are suggested as part of this task.

Task VII - Final Report. This task summarizes the work conducted in Task I through Task VI.

## 2.0 STUDY SUMMARY

The results of Task I through Task IV have been presented in Interim Reports. Task I, Levels of Protection, was given in Interim Report MSAR 79-36. Task II, Define Requirements, was presented in Interim Report MSAR 79-45. Task III, Testing Program, was given in Interim Report MSAR 79-52. Task IV was a report summarizing Tasks II and III. Task VII, this report, constitutes primarily work conducted in Task V, Material Compatibility Testing, and Task VI, Future R&D Efforts, as well as summarizing work performed in the other tasks.

### 2.1 Levels of Protection - Task I

The Coast Guard is responsible for dealing with spills of 985 hazardous chemicals. Safety equipment and levels of protection have been described to some extent in CHRIS Volumes I, II, III (1978). The basic objective of this task was to determine the degree of protection required as a function of the physical, chemical and toxicological characteristics of each of the 985 chemicals. Levels of protection along with other available pertinent information are given in Appendix A.

In establishing levels of protection, it was assumed that a worst case condition would exist at the spill site. Members of the strike cleanup team could be exposed to high and unknown air concentrations of the spilled chemical. Leaking rail cars, trucks or barges could result in direct contamination of the skin with large quantities of the chemical. Members of the crew could be required to enter contaminated waterways to erect dikes or dams and thus be exposed directly to high levels of the contaminant. Since exposure levels are incident dependent, and cannot be predicted, maximum levels of protection are recommended for the initial entry to the area by the members of the strike team. Once the severity and associated hazards of the spill have been identified, a lower level of protection could be used.

Basic premises made to evaluate potential hazards posed by hazardous chemical spills to recommend protective clothing and respiratory equipment were:

1. Guidelines used to evaluate the hazard should cover all modes of entry into the body and should be based upon acute exposures.
2. The recommended protective equipment should be classified into three basic categories to minimize stocking, storing and logistic problems.

In this task, the basic source of information was Sax's ranking of hazard levels ranging from 3, a severe hazard to 0, the least hazard. These values are based on acute exposures and not on chronic exposures. Effects of exposure relate to inhalation, percutaneous (skin absorption) and skin irritation hazards.

An inhalation hazard of 3 and a skin irritant of 3 constituted rationale for use of a sealed suit for any chemical whether liquid, solid, or gaseous state. Where a 3 appears under respiratory hazard, the use of an air line supply or complete respiratory support without recourse to ambient atmosphere at the point of the spill is dictated.

This leaves the middle ground of a 2 categorization where some judgment is required. A 1 category in either contact, percutaneous or respiratory effects can be handled by individual items of protection other than the fully encapsulating sealed suit.

#### 2.1.1 Rationale for Establishing Levels of Protection

There are a number of sources which can provide guidelines for selection of protection levels. References 1-9 given in the Bibliography were the primary references used.

Threshold Limit Values, Short Term Exposure Limits and Excursion Limits have been developed to provide a safe environment for workers who may be exposed to toxic contaminants during a normal routine work cycle. These values are useful in maintaining healthful work environments, and in some cases provide relative toxicity data among various classes of contaminants. Concentrations at or below the recommended TLV and STEL require no protective equipment; in the case of massive hazardous chemical spills, it must be assumed that the ambient air concentration of the contaminant will exceed these values. Thus, TLV, STEL and EL values offer limited information on required levels of protection for concentrations exceeding these values.

Threshold Limit Values define chronic exposure levels where the worker is exposed to low concentrations for long periods of time. In the case of a hazardous chemical spill, the members of a Strike Team would likely suffer acute exposures of exceptionally high concentrations of hazard chemicals. In addition, the TLV's indicate those chemicals which may find their way into the body through the percutaneous route but they do not necessarily identify those that may be tissue irritants.

These limitations dictated the need for an alternate procedure for establishing levels of protection. Sax's Dangerous Properties of Industrial Materials provides a Toxic

Hazard Rating Code with information on both acute and chronic effects and assigns ratings based on the mode of action or entry, i.e., inhalation, ingestion, skin absorption and irritation.

The rationale used for establishing required levels of protection is based on the hazard rating code of Sax:

- 0 NONE:           (a) No harm under any conditions;  
                  (b) Harmful only under unusual conditions or overwhelming dosage.
- 1 SLIGHT:       Causes readily reversible changes which disappear after end of exposure.
- 2 MODERATE:     May involve both irreversible and reversible changes not severe enough to cause death or permanent injury.
- 3 HIGH:         May cause death or permanent injury after very short exposure to small quantities.
- U UNKNOWN:     No information on humans considered valid by authors.

These are applied to the routes of entry to the body, and the resultant effect such as:

Acute Local	Acute Systemic
Irritant	Ingestion
Ingestion	Inhalation
Inhalation	Skin Absorption

Table 1 lists the guidelines used in selecting protective equipment based upon toxicity rating, mode of entry, and physical form of the chemical. If a chemical is a carcinogen, a sealed suit was recommended. If a chemical has a 0 rating or is innocuous, it is recommended that strike team personnel wear standard safety equipment including hard hats, safety glasses, gloves, and steel-toed footwear in observance of good safety practices.

#### 2.1.1.1 Respiratory Protection

The first concern is respiratory protection, since this is the most likely exposure route, and is generally the most critical. Guides to selection of type and degree of respiratory protection equipment developed are presented in Tables 2,3 and 4.

TABLE 1 - GUIDELINES FOR SELECTION OF PERSONAL PROTECTION EQUIPMENT

Toxicity Rating	Mode of Entry	Response		
		Gas & Liquids <u>Respiratory</u>	<u>Clothing</u>	Solids <u>Respiratory</u>
0	Inhalation Skin Absorption Irritation	None required "	None required "	None required "
1	Inhalation Skin Absorption Irritation	Chemical filter <sup>2</sup> ----- -----	----- Nonsealed Nonsealed	Particulate ----- ----- Nonsealed Nonsealed
2	Inhalation Skin Absorption Irritation	Chemical filter <sup>2</sup> or air supply <sup>2</sup> ----- -----	----- ----- Nonsealed Nonsealed	Particulate & chemical filter ----- ----- Nonsealed Nonsealed
3	Inhalation Skin Absorption Irritation	Air supply <sup>3</sup> ----- -----	----- FES <sup>1</sup> FES <sup>1</sup>	Air supply <sup>3</sup> ----- FES <sup>1</sup> FES <sup>1</sup>

- <sup>1</sup>Fully encapsulating sealed suit indicates need for air supply  
<sup>2</sup>Contaminants in gaseous form at STP indicates need for air supply  
<sup>3</sup>Carcinogens indicate need for air supply

TABLE 2 - SELECTION OF RESPIRATORS FOR EMERGENCY OR SHORT-TERM USE  
ON THE BASIS OF HAZARD AND EXPECTED CONCENTRATION (Particulates)

Toxicity	Expected Concentrations of Particulate Matter (Dusts, Fumes and Mists)			
	Two to five times TLV	Five to twenty times TLV	Above twenty times TLV	Oxygen defi- cient, emer- gency, highly corrosive
Low	Respirator not usually needed	Filter	Filter or air- line respirator	Where expo- sure is to extremely corrosive dusts or to dusts in an oxygen defi- cient atmos- phere, a self- contained air or oxygen respirator must be used.
Moderate or High (tox- icity no greater than lead)	Filter	Filter or air- line respirator	Air-line or self-contained air or oxygen	
Extremely High (toxicity greater than lead)	Filter or air- line respirator	Air-line res- pirator	Self-contained air or oxygen	

NOTES:

- (1) TLV refers to the Threshold Limit Values for a number of substances published by the American Conference of Governmental Industrial Hygienists (Sections 1, 12).
- (2) See Sections 1 and 2 for a discussion of toxicity ratings and their relation to TLV's.
- (3) Expected concentrations of particulate matter have been shown only as multiples of the threshold limit values. Where these values are not available, the following concentrations may be used as a guide:

	Mineral Dusts	Other Dusts, Fumes, and Mists
2 to 5 (TLV)	up to 50 mppcf*	Up to 0.5 milligrams per cubic meter
5 to 20 (TLV)	50 to 1000 mppcf*	0.5 to 10 milligrams per cubic meter
Above 20 (TLV)	above 1000 mppcf*	Above 10 milligrams per cubic meter

- (4) When unavoidable conditions necessitate using respirators for longer periods (above 1 hour), use equipment in a higher protective category than shown above.
- (5) Subject to limitations (Table 2.1), hose-type respirators may be used in place of air line.

\* Mppcf = millions of particles per cubic foot.

From Sax, N.I., Dangerous Properties of Industrial Materials, Fifth Edition, p. 47, Van Nostrand Reinhold Company, New York (1979).

TABLE 3 - PROTECTION FACTOR FORMULA (12)

$$\text{protection factor (PF)} = \frac{\text{ambient air concentration}}{\text{concentration inside facepiece or enclosure}}$$

Protection Factor	Respirator Efficiency (%)	Facepiece Penetration (%)	Selection Guide for Maximum Use Concentration (× TLV)
5	80	20	5
10	90	10	10
20	95	5	20
50	98	2	50
100	99	1	100
200	99.5	0.5	200
500	99.8	0.2	500
1,000	99.9	0.1	1,000
2,000	99.95	0.05	2,000
5,000	99.98	0.02	5,000
10,000	99.99	0.01	10,000

From Patty's Industrial Hygiene and Toxicology, Vol. 1, 3rd Revised Edition, p. 1035, John Wiley & Sons, New York (1978)

TABLE 4 - RESPIRATORY PROTECTION FACTORS (12)

Type Respirator	Facepiece <sup>a</sup> Pressure	Protection Factor
I. Air purifying		
A. Particulate <sup>c</sup> removing		
Single-use, <sup>d</sup> dust <sup>e</sup>	-	5
Quarter mask, dust <sup>f</sup>	-	5
Half mask, dust <sup>f</sup>	-	10
Half or quarter mask, high efficiency <sup>h</sup>	-	10
Half or quarter mask, fume <sup>g</sup>	-	10
Full facepiece, high efficiency	-	50
Powered, high efficiency, all enclosures	+	1,000
Powered, dust or fume, all enclosures	+	— <sup>i</sup>
B. Gas and vapor removing <sup>j</sup>		10
Half mask	-	50
Full facepiece	-	
II. Atmosphere supplying		
A. Supplied air		
Demand, half mask	-	10
Demand, full facepiece	-	50
Hose mask without blower, full facepiece	-	50
Pressure demand, half mask <sup>k</sup>	+	1,000
Pressure demand, full facepiece <sup>l</sup>	+	2,000
Hose mask with blower, full facepiece	-	50
Continuous flow, half mask <sup>k</sup>	+	1,000
Continuous flow, full facepiece <sup>l</sup>	+	2,000
Continuous flow, hood, helmet, or suit <sup>m</sup>	+	2,000
B. Self contained breathing apparatus (SCBA)		
Open circuit, demand, full facepiece	-	50 <sup>n</sup>
Open circuit, pressure demand full facepiece	+	10,000
Closed circuit, oxygen tank-type, full facepiece	-	50
III. Combination respirator		
A. Any combination of air-purifying and atmosphere-supplying respirator		Use minimum protection factor listed above for type of mode of operation.
B. Any combination of supplied-air respirator and an SCBA		

*Exception:* Combination supplied-air respirators, in pressure demand or other positive pressure mode, with an auxiliary self-contained air supply, and a full facepiece, should use the PF for pressure demand SCBA.

<sup>a</sup>The overall protection afforded by a given respirator design (and mode of operation) may be defined in terms of its protection factor (PF). The PF is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of contaminant in the ambient atmosphere to that inside the enclosure (usually inside the facepiece) under conditions of use. Respirators should be selected so that the concentration inhaled by the wearer will not exceed the

From Patty's Industrial Hygiene and Toxicology, Vol. 1, 3rd Revised Edition, p. 1036, John Wiley & Sons, New York (1978)

TABLE 4 (continued)

appropriate limit. The recommended respirator PFs are selection and use guides, and should only be used when the employer has established a minimal acceptable respirator program as defined in Section 3 of the ANSI Z88.2-1969 Standard.

\* In addition to facepieces, this includes any type of enclosure or covering of the wearer's breathing zone, such as supplied-air hoods, helmets, or suits.

\* Includes dusts, mists, and fumes only. Does not apply when gases or vapors are absorbed on particulates and may be volatilized or for particulates volatile at room temperature. Example: Coke oven emissions.

\* Any single-use dust respirator (with or without valve) not specifically tested against a specified contaminant.

\* Single-use dust respirators have been tested against asbestos and cotton dust and could be assigned a PF of 10 for these particulates.

\* Dust filter refers to a dust respirator approved by the silica dust test and includes media of all types, that is, both nondegradable mechanical-type media and degradable resin-impregnated wool felt or combination wool-synthetic felt media.

\* Fume filter refers to a fume respirator approved by the lead fume test. All types of media are included.

\* High efficiency filter refers to a high efficiency particulate respirator. The filter must be at least 99.97 percent efficient against 0.3  $\mu$ m DOP to be approved.

\* To be assigned, based on dust or fume filter efficiency for specific contaminant.

\* For gases and vapors, a PF should be assigned only when published test data indicate that the cartridge or canister has adequate sorbent efficiency and service life for a specific gas or vapor. In addition, the PF should not be applied in gas or vapor concentrations that are (1) immediately dangerous to life, (2) above the lower explosive limit, and (3) cause eye irritation when using a half mask.

\* A positive pressure supplied-air respirator equipped with a half-mask facepiece may not be as stable on the face as a full facepiece. Therefore, the PF recommended is half that for a similar device equipped with a full facepiece.

\* A positive pressure supplied-air respirator equipped with a full facepiece provides eye protection but is not approved for use in atmospheres immediately dangerous to life. It is recognized that the facepiece leakage, when a positive pressure is maintained, should be the same as an SCBA operated in the positive pressure mode. However, to emphasize that it basically is not for emergency use, the PF is limited to 2000.

\* The design of the supplied-air hood, suit, or helmet (with a minimum of 170 liters/min of air) may determine its overall efficiency and protection. For example, when working with the arms over the head, some hoods draw the contaminant into the hood breathing zone. This may be overcome by wearing a short hood under a coat or overalls. Other limitations specified by the approval agency must be considered before using in certain types of atmospheres.

\* The SCBA operated in the positive pressure mode has been tested on a selected 31-man panel and the facepiece leakage recorded as  $\leq 0.01$  percent penetration. Therefore, a PF of 10,000+ is recommended. At this time, the lower limit of detection 0.01 percent does not warrant listing a higher number. A positive pressure SCBA for an unknown concentration is recommended. This is consistent with the 10,000+ that is listed. It is essential to have an emergency device for use in unknown concentrations. A combination supplied-air respirator in pressure demand or other positive pressure mode, with auxiliary self-contained air supply, is also recommended for use in unknown concentrations of contaminants immediately dangerous to life. Other limitations, such as skin absorption of HCN or tritium, must be considered.

Guidelines for selection of respirators for emergency or short-term use have been based on relative toxicity factors and expected concentrations (Table 5). Protection factors have been developed based on respiratory cartridge efficiency, ambient air concentration and facepiece characteristics (Tables 3-4).

Numerous problems exist in formulating recommendations for Strike Team personnel exposed to gaseous and liquid chemical spills. These include:

1. The logistics problems involved in storing and maintaining a variety of respiratory canisters and facepiece ensembles.
2. The unknown and perhaps variable air concentrations existing in the area of the spill.
3. Lack of information on specific canisters which can be used for many of the 985 chemicals.
4. Variable canister lifetimes depending upon the type and concentration of chemical.

Respiratory protection against solid, nonvolatile chemical spills is more easily defined and requires basically a high efficiency particulate filter cartridge; solids with moderate vapor pressures could require a combination particulate-chemical canister.

#### 2.1.1.2 Protective Clothing

Types of protective clothing classifications can be considered to be:

1. Whole body fully encapsulating sealed suits
2. Whole body nonsealed suits
3. Partial body clothing items

An example of a whole body encapsulating sealed suit is the Hazardous Chemical Protective Clothing Outfit, HCPCO (POTMC Army designation). This suit is made of butyl rubber with a polycarbonate fishbowl helmet. This suit provides full body protection for dealing with those chemicals which require whole body protection. Because it is fully sealed, an environmental control unit is used with the suit to provide the wearer with respiratory air and cooling.

TABLE 5 - SELECTION OF RESPIRATORS FOR EMERGENCY OR SHORT-TERM USE  
ON THE BASIS OF HAZARD AND EXPECTED CONCENTRATION (Gases and Vapors)

Toxicity	Expected Concentrations of Gases or Vapors			
	Two to five times TLV or up to 1000 ppm	Five to ten times TLV or 1000-5000 ppm	Above ten times TLV or 5000-20,000 ppm	Oxygen defi- ciency, emer- gency or above 20,000 ppm
Low	No respirator, or chemical cartridge needed	Canister gas mask	Canister gas mask or air- line respirator	Self-contained air or oxygen
Moderate	Chemical car- tridge	Canister gas mask or air- line respirator	Air-line or self-contained air or oxygen	Self-contained air or oxygen
High	Canister gas mask	Air-line res- pirator	Self-contained air or oxygen	Self-contained air or oxygen

**Notes:**

- (1) TLV refers to the Threshold Limit Values for a number of substances published by the American Conference of Governmental Industrial Hygienists (see Section 1 and section 12).
- (2) See Sections 1 and 2 for a discussion of toxicity ratings and their relation to TLV.
- (3) When unavoidable conditions necessitate using respirators for longer periods (above 1 hour), use equipment in a higher protective category than shown above.
- (4) Subject to limitations (Table 2.1), hose-type respirators may be used in place of air line.

From Sax, N.I., Dangerous Properties of Industrial Materials,  
Fifth Edition, p. 47, Van Nostrand Reinhold Company, New York  
(1979).

Part of this task effort was to list those chemicals which require a whole body encapsulating sealed suit (HCPCO). A majority of the chemicals will require protective clothing less sophisticated than the HCPCO type suit and in some cases no special protective clothing at all.

Advisement of types of protective clothing available other than whole body encapsulating sealed suits was a part of Task I work goals.

Protective clothing manufacturers were contacted to obtain clothing and chemical compatibility data. A list of organizations surveyed is given in Table 6. Appendix B lists the specific types of protective devices available from suppliers.

Some chemical compatibility information is available in protective clothing equipment brochures but is limited in the number of chemicals. Chemical compatibility data for clothing materials is presented only as a guideline and the manufacturer does not guarantee any specific chemical compatibility/clothing performance. Protective clothing manufacturers will provide sample swatches and advise that those interested in their protective clothing products conduct testing and evaluation themselves. Complete compatibility data on all 985 chemicals listed in CHRIS was not obtainable from manufacturers data sources and therefore testing was required in many cases.

Types of protective clothing items include gloves, boots, aprons, hoods, coveralls, pants, jackets, coats, one and two piece suit combinations as well as whole body encapsulating sealed suits. The majority of protective clothing is polyvinyl chloride coated on nylon or cotton fabric material. Rubber and urethane fabric materials are also available. TYVEK (duPont trademark) is a lightweight polyethylene fabric material which is low cost and generally used for throw-away type protective apparel. Butyl rubber protective clothing garments are top of line in cost. Unfavorable cost and manufacturing problems have detracted from Teflon as a protective clothing material although it would be the most chemical resistant of all materials.

#### 2.1.2 Summary and Conclusions

The 985 chemicals were reviewed and levels of protection were established based on Sax's Toxic Hazard Rating. It had been estimated initially that perhaps 100 of the chemicals would require a full encapsulating garment. The rationale used in this study indicated that 403 chemicals may require a fully encapsulating sealed suit with an air supply.

Information is available on the compatibility of many of the chemicals with the standard butyl rubber-polycarbonate

## TABLE 6 - REFERRAL LIST

### (Protective Clothing)

#### ORGANIZATION

1. Clever Maid Uniform Company
2. Singer Safety Products Company
3. Boss Manufacturing Company, Ind. Division
4. Clark, David, Company, Inc.
5. Advance Glove Manufacturing Company
6. Star Glove Company
7. Shaffer Products
8. Texier, H. Glove Company, Inc.
9. Colonial Uniform Manufacturing Corporation
10. Loveline Industries, Inc.
11. Fyrepel Products, Inc.
12. Fabohic Inc.
13. Plastimayd Corporation
14. Wheeler Protective Apparel, Inc.
15. Titan Abrasive Systems, Inc.
16. Guardian Safety Equipment Company
17. Norton Company Safety Products Division
18. Encon Manufacturing Company
19. Mine Safety Appliances Company
20. East Wind Industries
21. Army Research Center
22. DuPont de Nemours & Company
23. Arrowhead Products, Division Federal Mogul
24. International Latex Corporation
25. Rich Industries (Snyder Manufacturing Company)
26. Standard Safety and Equipment Company
27. Edmont-Wilson Division, Bechton Dickinson & Company
28. JOMAC Products, Inc.
29. Plymouth Rubber Company

encapsulating suit. However, the information is not complete and compatibility tests were required for those cases where compatibility was not known.

In summary, of the 985 chemicals reviewed, it was concluded that 403 chemicals would require a fully sealed suit. There were 44 chemicals in which a decision could not be made and these are given in Table 7. Fifteen chemicals are pyrophoric requiring a fire suit; these are listed in Table 8.

Appendix C lists the 403 chemicals in the test program which are discussed later in this report.

## 2.2 Requirements - Task II

Requirements given herein apply to clothing material sought to provide head and body protection to personnel who will encounter chemicals of all types of reactivity groups.

The list of requirements for candidate materials is given in Table 9.

### 2.2.1 Service Time

Time period within a fully sealed suit shall be a maximum of two (2) hours based upon the physiological impact of wearing the suit.

First level requirement for candidate material shall be twenty (20) hours chemical resistance time. This requires that the candidate material be exposed for a twenty (20) hour contact time without damage and represents ten (10) wear cycles and associated decontamination.

A secondary protection level requirement for the candidate material shall have a chemical resistance service time of two (2) hours. This represents the absolute minimum wear time for a single use duty during which no catastrophic degradation of material is permissible to jeopardize personnel welfare.

Because of associated cost, a multiple wear cycle material is desired over a single wear cycle material. However, a single wear cycle material should be given consideration as an acceptable alternative.

### 2.2.2 Shelf Life

Candidate material shall have a shelf life period of ten (10) years when properly stored to prevent premature aging. Chemical resistance and durability properties during its shelf life period shall not be affected.

TABLE 7 - CHEMICALS WITH UNASSIGNED LEVELS OF PROTECTION

<u>CHRIS Code</u>	<u>Chemical Name</u>	<u>State</u>
AEA	n-Aminoethylethanolamine	L
ALS	Ammonium Lauryl Sulfate	L
AMT	Ammonium Thiocyanate	S
AMY	n-Amyl Chloride	L
BZP	Benzophenone	S
BBP	Benzyl n-Butyl Phthalate	L
BZO	Benzyl Dimethyl-Octa-Decyl Ammonium Chloride	L
BMA	Benzyltrimethyl Ammonium Chloride	L
BDO	1,3-Butanediol	L
BUD	1,4-Butenediol	L
CPH	Camphene	S
CLS	Caprolactum Solution	L
CAR	Carene	L
CRN	p-Chlorotoluene	L
COS	Cobalt Sulfamate(ous)	-
CGE	Cresyl Glycidyl Ether	S
DES	2,4-D Esters	L
DBZ	n-Decylbenzene	L
DIC	Dicamba	S
DSD	Dodecylsulfate, Diethanolamine Salt	L
DSM	Dodecylsulfate, Magnesium Salt	L
DDS	Dodecylsulfate, Sodium Salt	S
DST	Dodecylsulfate, Triethanolamine Salt	L
DAI	Dodecylbenzene Sulfonic Acid, Isopropanolamine Salt	S
EHP	Ethoxydihydropyran	L
EBR	Ethylbutyrate	L
ETN	Ethylnitrite	L/G
IPC	Isopropyl Percarbonate	S
MCP	Methylcyclopentane	L
MPA	Monoisopropanolamine	L
OET	Octyl Epoxy Tallate	L
ORS	Oil Misc., Resin	L
ORD	Oil Misc., Road	L
ORN	Oil Misc., Rosin	L
OSP	Oil Misc., Sperm	L
OCF	Oil Misc., Clarified	L
PPB	Phosphorous, Black	S
SAS	Silver Aklyl Sulfates	S
SFL	Sulfolane	L
TRN	Thorium Nitrate	S
UDB	n-Undecylbenzene	L
URA	Uranyl Acetate	S
VEE	Vinyl Ethyl Ether	L/G
ZDP	Zinc Dialkyldithiophosphate	L

## TABLE 8 - PYROPHORIC CHEMICAL LIST

(Fire Suit)

<u>CHRIS Code</u>	<u>Chemical Name</u>	<u>State</u>
CRE	Calcium Resinate	S
DBR	Decaborane	S
DEZ	Diethyl Zinc	L
DMZ	Dimethyl Zinc	L
EAD	Ethylaluminum Dichloride	L
EAS	Ethylaluminum Sesquichloride	L
NKC	Nickel Carbonyl	L
PTB	Pentaborane	L
PPR	Phosphorous, Red	S
PPW	Phosphorous, White	S
PTM	Potassium, Metallic	S
SDU	Sodium, Metallic	S
SZA	Sodium Azide	S
TIA	Triisobutylaluminum	L
TAL	Triethylaluminum	L

TABLE 9 - MATERIAL REQUIREMENT SUMMARY

<u>Para-graph</u>	<u>Item</u>	<u>Requirement</u>
2.2.1	<u>Service Time</u>	
	Wear Time	2 hours
	Chemical Service Time	
	Primary level	20 hours
	No. wear cycles	10
	Secondary level	2 hours
	No. wear cycles	1
2.2.2	<u>Shelf Life</u>	10 years
2.2.3	<u>Ambient Work Conditions</u>	
	Pressure	1 Atmosphere (Air with no contaminant to 100% contaminant)
	Temperature	-30°C (-22°F) to 40°C (104°F)
	Humidity	Up to 100% and water contact
	Sunlight	No UV or O <sub>3</sub> degradation
	Fungus	Will not support mold growth
2.2.4	<u>Temperature Characteristics</u>	
	Operational and storage temperatures, -30°C (-22°F) to 70°C (158°F) range	Noncracking, tackiness, stiffening, flaking or separation
2.2.5	<u>Durability</u>	Meet physical properties per MIL-C-12189E, Table 1
2.2.6	<u>Odor</u>	No offensive odors
2.2.7	<u>Toxicity</u>	No inherent toxicity hazard
2.2.8	<u>Fabrication Methods</u>	Sewed, glued, heat bonded impulse heated, sonic bonded, radio frequency bonded or other method to provide leak tight joints Capable of bonding to other acceptable materials Field and factory repairable

TABLE 9 - MATERIAL REQUIREMENT SUMMARY (cont.)

<u>Para-graph</u>	<u>Item</u>	<u>Requirement</u>
2.2.9	<u>Workmanship</u>	Material conforms to quality and grade per these requirements
2.2.10	<u>Support and Maintenance</u>	Provide data and procedure to sanitize, leak check, seal, repair, inspection, optical quality, storage- record keeping
2.2.11	<u>Decontamination</u>	Material does not degrade from decontamination procedures
2.2.12	<u>Material and Production Cost</u> Material Cost Range	\$10-\$50 per square yard Variable depending upon garment material
2.2.13	<u>Chemical Compatibility</u> (985 CHRIS List Chemicals)	100% compatibility desired
2.2.14	<u>Other Requirements</u>	Impermeable Fire retardant Static electricity free
2.2.15	<u>Intended Use</u>	Protective garment

### 2.2.3 Ambient Work Conditions

Candidate materials shall be capable of exposure to contaminated air with contaminant concentrations ranging from 0 to 100%. Candidate materials must be able to withstand a temperature range of -30°C (-22°F) to 40°C (104°F), a humidity of 100% and water content, have no ultraviolet light or ozone degradation and be fungus resistant.

### 2.2.4 Temperature Characteristics

Over a temperature range of -30°C (-22°F) to 40°C (104°F) ambient work conditions and storage conditions of -30°C (-22°F) to 70°C (158°F), material shall not exhibit cracking, become tacky, exhibit stiffening, flaking or separation from these temperature extremes.

### 2.2.5 Durability

Candidate material shall be resistant to abrasion, scuffing and tearing. Physical property data for butyl rubber per MIL-C-12189E, Table 9 shall apply as a material durability requirement.

### 2.2.6 Odor

Candidate material shall not have an offensive odor.

### 2.2.7 Toxicity

Candidate material shall not in itself present a toxicity hazard.

### 2.2.8 Fabrication Methods

Candidate materials shall possess suitable fabrication characteristics. Material for body protective garments shall be sufficiently flexible so as not to impede body movement.

Candidate material shall be capable of being fabricated to produce leak-free seams by sealing, sewing, gluing, heat bonding, impulse heating, sonic bonding, radio-frequency bonding, and other methods. Bonding to other acceptable materials as well as to itself is also desirable.

It is required that material be capable of repair in the field for minor tears or at the fabricator shop for more major tears to salvage the protective ensemble.

### 2.2.9 Workmanship

Finished material shall conform to the quality and grade of product established by these requirements.

#### 2.2.10 Support and Maintenance

Support and maintenance procedures shall be required for proper care of protective clothing materials. Information shall be provided on:

1. sanitizing after use
2. leak checking
3. leak sealing
4. major and minor repairs
5. inspection for chemical attack
6. checking optical quality of transparent materials
7. storage
8. record keeping

Material requirements are based upon appropriate care: storage in uncreased condition, prompt decontamination and sanitization, proper inspection and repairs.

#### 2.2.11 Decontamination

Candidate material shall be capable of being decontaminated to recondition for additional service. Decontamination procedures might include, in addition to others, such procedures as:

1. Water wash or flush.
2. Water wash with detergent.
3. Wash with neutralizing agent.
4. Wash or wipe with appropriate solvents.
5. Brushing or other means of removing contaminants.

Decontamination procedures shall be based upon consideration that contaminants might be solids or liquid residual. Decontamination shall be considered to apply to both external and internal surfaces. Decontamination shall not deteriorate material for additional wear cycles.

#### 2.2.12 Material and Production Costs

Material unit cost and fabrication cost data shall be supplied. Cost level shall be considered for making analysis of

the material's suitability in relation to the Coast Guard's purposes and use. Material costs in the range of \$3.50 per square yard are typical of protective clothing materials; cost for special runs may be in the range of \$10 per square yard. Material costs generally are minor costs of the total cost; fabrication and quality control costs are the major cost. Material scrap shall be in the range of 7-10% so that material costs do not become a greater portion of total cost. A material cost of \$20 per square yard shall not be considered excessive if service life compared to \$10 per square yard is more than doubled. Based upon material unit cost range of \$3.50 to \$20 per square yard, material costs per ensemble shall be in the range of \$20 to \$120.

It is recognized that fabrication costs will depend primarily upon specific requirements for the suit. The magnitude of the costs will depend upon any special research, development and engineering time to develop a protective suit. Furthermore, protective clothing ensembles manufactured to applicable MIL specifications and to specific design features entail greater cost. Cost targets cannot be established until a final selection is made of garment requirements for each of the chemicals.

#### 2.2.13 Material Chemical Compatibility Data

Data shall be provided on the number and types of chemicals which the candidate material is compatible with so assessment of its applicability can be made. Preliminary evaluation of the candidate material may be judged on basis of chemical reactivity groups, however some exceptions are likely to be found within a reactivity group. Comparison of each of the 985 chemicals given in the CHRIS list against the candidate material shall be made. Data shall consist of the percent compatible with the chemicals and a listing of those which are not and a list for those for which information is not available.

As an example, a data search indicated butyl rubber was compatible with about 70% of the chemicals:

No. compatible	685
No. incompatible	119
No. unknown	<u>111</u>
TOTAL	985

For polycarbonate, the compatibility was approximately 56%:

No. compatible	553
No. incompatible	153
No. unknown	<u>279</u>
TOTAL	985

## 2.2.14 Other Requirements

Candidate materials shall be impermeable, fire retardant, and not exhibit static electricity properties.

## 2.2.15 Intended Use

Candidate materials shall be fabricated for assembly of a protective garment. This protective garment shall be used by Coast Guard Strike Team personnel in cleanup operations that include 985 CHRIS list chemicals.

## 2.3 Testing Program (Plan) - Task III

Levels of protection investigated during Task I indicated 403 chemicals required a sealed suit out of 985 chemicals involved. An additional 15 chemicals were pyrophoric and were assigned to a fire suit. Another 44 chemicals were indeterminate and a level of protection was unassigned. The remaining 523 chemicals were assigned levels of protection of an unsealed suit or use of standard safety equipment; i.e., gloves, goggles, hard hats and steel-toed footwear.

Of the 403 chemicals requiring sealed suits, 327 were specified by use of Sax's Toxic Hazard Rating and the remaining 76 chemicals were determined by other standards and best judgments. A total of 403 chemicals were candidates for the Material Compatibility Testing, Task V.

A program plan was devised with the objective to assign a performance rating for each of the 403 chemicals of interest.

In general, a Performance Rating Guide for chemicals requiring a sealed suit would evolve from the evaluation of available literature compatibility and the outcome of extensive tests conducted at MSAR. There were, however, several overriding factors which prevented the straightforward application of published data. The developmental process used to generate performance ratings is detailed below and is summarized in Figures 1 and 2.

### 2.3.1 Applicability of Literature Data

Numerous materials selection guides have been published detailing the compatibility of certain plastics and rubbers with various chemicals. Unfortunately, the basis for this information is unclear or not revealed. Realistically, it would have been impractical to ignore this extensive data source in its entirety. As a result, guidelines were developed to distinguish the type data which could be accepted at face value. The following rationale concerning published literature compatibility data was used.

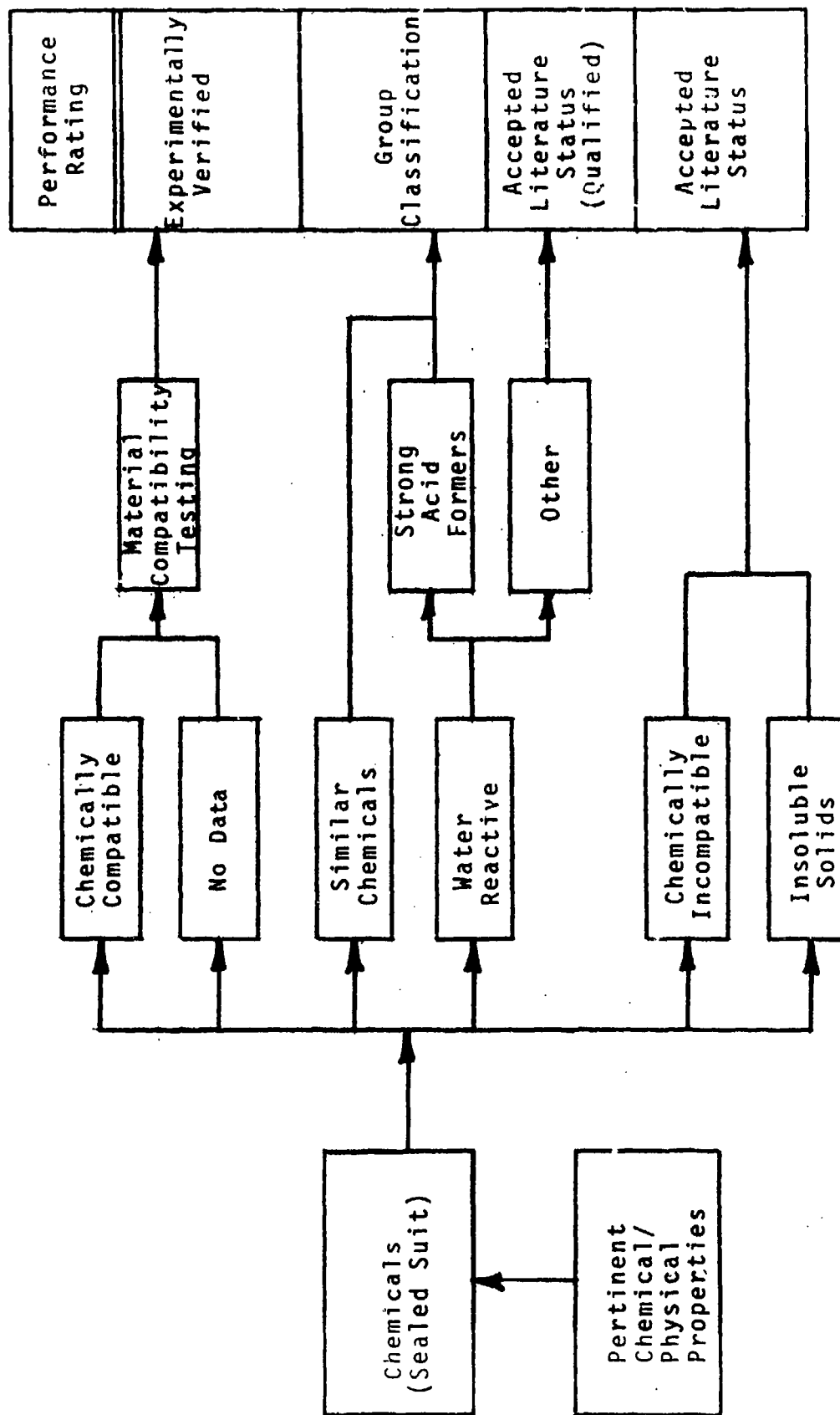


FIGURE 1 - BUTYL RUBBER PERFORMANCE RATING EVALUATION PLAN

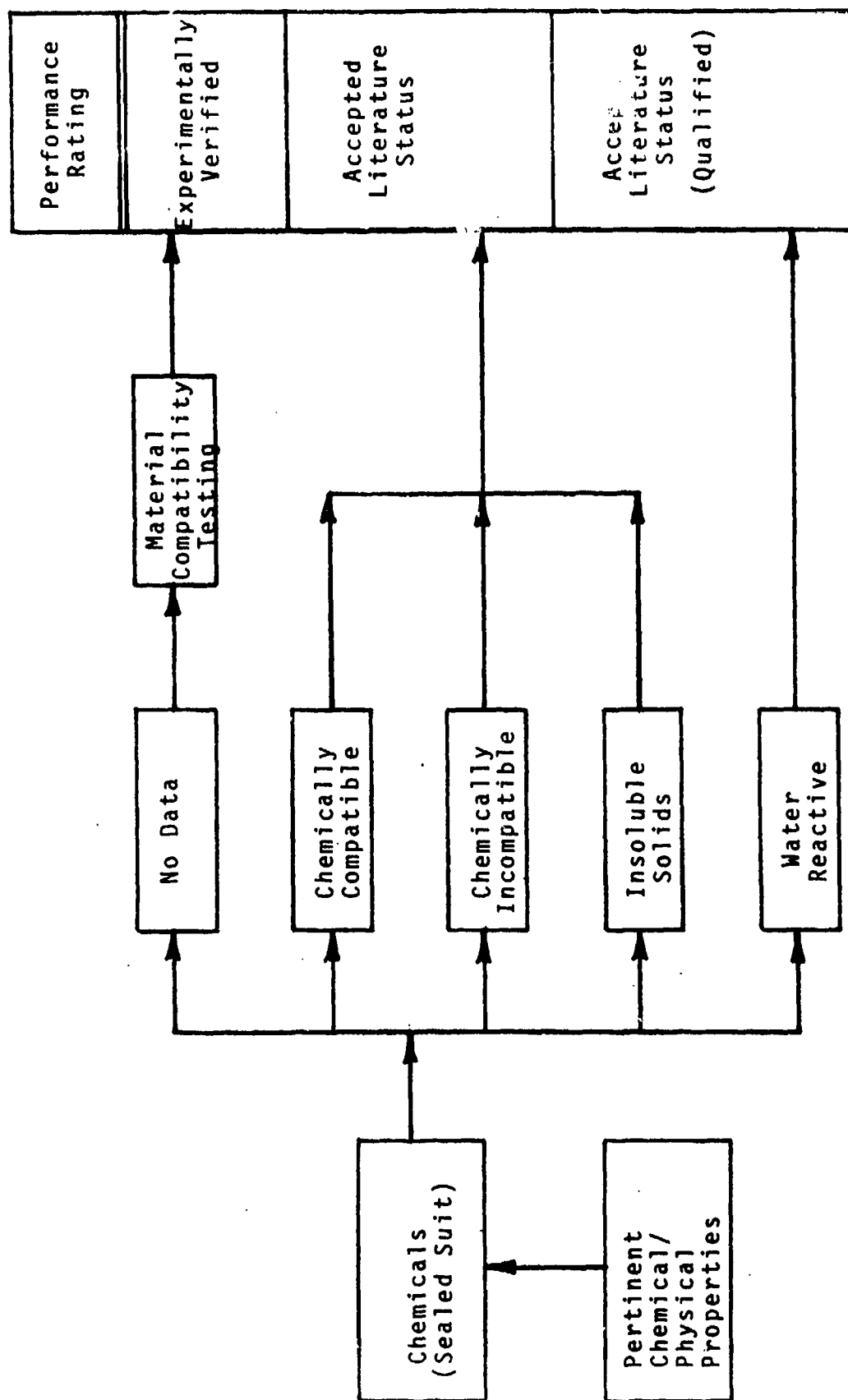


FIGURE 2 - POLYCARBONATE PERFORMANCE RATING EVALUATION PLAN

#### 2.3.1.1 Polycarbonate

The literature findings (compatible or noncompatible) were used without further consideration. It was concluded that valid and applicable type testing have been performed. Key test factors such as resistance to fogging, softening, discoloration, etc., would undoubtedly have been included in these tests. Testing at MSAR was limited therefore only to those chemicals for which no data could be uncovered. Over 100 chemicals fell into "no data" classification and were subsequently tested at MSAR.

#### 2.3.1.2 Butyl Rubber

A literature finding of "incompatible" or "unsatisfactory" of the chemical with butyl rubber was accepted as an unacceptable rating. It was confidently anticipated that the application of more extensive and rigorous testing would only confirm this data. On the other hand, a literature rating of "compatible" was not accepted because of the uncertainty of the test methods and the increased requirements demanded of a protective sealed suit, e.g., penetration data.

In addition to the shortcomings of the published data, there were other factors which were inherent in the chemicals themselves which influences the methods of generating a final rating guide. Three distinct classes of chemicals were singled out and treated separately, i.e., water reactive, insoluble solids and similar group classifications.

#### 2.3.2 Water Reactive Chemicals

It was concluded that literature information concerning chemicals that could react with water applied only to the unreacted chemical, whereas mixtures of uncertain composition would exist in the field. Detailed laboratory studies of these chemicals were not undertaken partly because the field composition would be situation dependent. Performance Rating Guides for water reactive chemicals were generated in the following manner.

##### 2.3.2.1 Polycarbonate

The accepted chemical compatibility literature findings were retained, however the rating would be qualified by noting that it applied only to the unreacted chemical.

##### 2.3.2.2 Butyl Rubber

Specialized laboratory tests eventually showed that reactive chemicals which yielded strong acid decomposition products would eventually prove harmful to butyl rubber. This class of reactive chemicals was categorically given a "Fail" rating.

The literature data was retained for chemicals yielding lesser reactive materials. In this latter case, the rating was qualified and limited to the unreacted chemical.

The subject of water reactive chemicals and their effects on butyl rubber is detailed in a later section.

### 2.3.3 Insoluble Solids

No tests were scheduled on solid chemicals which were found to be insoluble in water. It was concluded that this general class of chemical could only penetrate the protective ensemble via mechanical defects such as holes, tears, faulty seams, etc. However, the possibility persisted that these chemicals could still chemically attack butyl and polycarbonate. The literature findings were subsequently adopted with no qualifications.

### 2.3.4 Similar/Group Classification

The overall plan provided for the classification of certain chemicals based on their close chemical relationship. In the event that chemicals could not be evaluated either experimentally or on the basis of literature data, such chemicals should be assigned a rating based on chemical similarity. The number of chemicals assigned a rating on this basis would be held to a minimum and the rating would only be assigned where proven or obvious trends existed.

### 2.3.5 Material Test Sequence

The overall evaluation plans shown in Figure 1 and 2 provide for a laboratory study to assess the compatibility of the chemical with butyl rubber and polycarbonate. The laboratory test program was limited to chemicals whose assigned literature rating was unknown and/or unaccepted. A Performance Rating Guide for these chemicals was generated by subjecting butyl rubber and polycarbonate to the chemicals in a series of selected and related tests. The laboratory test sequence is shown in Figure 3.

The selected time frames for these tests were 3 hours and 20 hours. A 3-hour time limit was intended to safely simulate a single mission in which the duration of exposure would be limited to about 2 hours. The 20-hour time frame for testing evolved from the consideration that the protective ensemble would be used for at least ten 2-hour periods. In this case, a 20-hour continuous exposure to the chemical was comparable or safely in excess of the demand posed by multi-short term use. The 20-hour test was not rigorously equated to 10 missions although this is implied. A brief description of the individual tests is described next. A detailed discussion of the experimental program is included in Section 3.0.

#### 2.3.5.1 Swatch Test

All chemicals selected to be tested were routed initially through a basic compatibility test. The intended purpose was to immediately eliminate chemicals which grossly attacked the test specimens. The duration of the test was 20 hours in which the specimens of polycarbonate and butyl rubber were maintained completely submerged (liquid) or engulfed (gas) by the chemical.

The test specimens were examined after 3-hour contact and again after 20 hours. Quantitative data which were recorded were weight and dimensional changes and any visually apparent indications of attack; i.e., cracking, blistering, tackiness, discoloration, fogging, etc. Special physical property testing was performed on the butyl specimen following the 20-hour contact. These tests were limited to the measurement of tensile and tear strength (warp direction).

A greater than 10% change in weight and/or physical properties was selected as a fail criterion. Chemicals found to attack the test specimen within 3 hours were assigned a failed rating. Chemicals passing 3 hours but failing in 20 hours were retained in the test program, as shown in Figure 3 for concentration versus time testing.

#### 2.3.5.2 Penetration Test (Butyl Rubber)

Chemicals advancing beyond the Swatch Test were subjected to penetration or permeation tests, which was the heart of the test program. The penetration test was limited to butyl rubber. Specimens of butyl rubber were contained in specially designed cells with the test chemical applied to the outer, thicker coated side. Clean air continuously purged the underside and suitable analytical techniques were used to measure the extent of penetration. Penetration by the nonvolatile inorganics was determined by swabbing the underside of the butyl specimen. The extent of penetration was measured at the end of 3 hours and/or at 20 hours.

The established fail criterion for the penetration test was the presence of positive signs of penetration. The criterion, which basically is dependent upon the sensitivity or detection limits of the analytical methods, was preferred over the general approach of establishing an allowable safe limit. The latter approach would have involved making uncertain toxicological decisions especially in instances where TLV type information was not available.

On the basis of the above, chemicals penetrating the butyl rubber within 3 hours were eliminated from further testing.

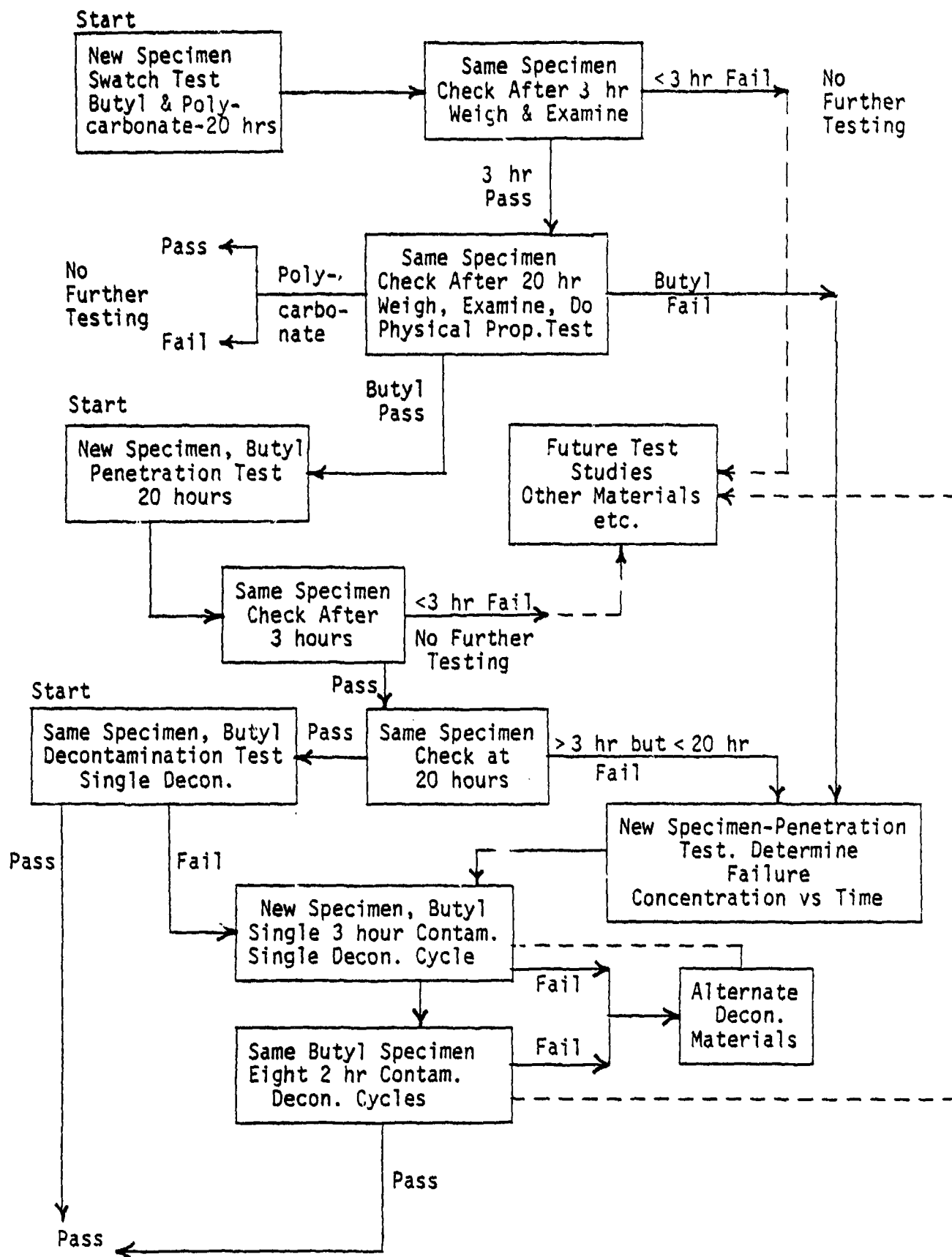


FIGURE 3 - MATERIAL COMPATIBILITY TESTING SEQUENCE

As is shown in Figure 3, chemicals breaking through the specimen between 3 and 20 hours were subjected to a concentration versus time test to determine service time. Chemicals passing the 20-hour test advanced to the Single Decon Test.

#### 2.3.5.3 Single Decon Test

Butyl rubber specimens which passed the 20-hour penetration test were given a single decon test. A single decon test consisted of a cold water wash with 1% detergent. The specimen was then checked for decontaminating effectiveness. Any detection of the chemical (see paragraph 2.3.5.2 above) on the butyl rubber represented a fail status. When butyl rubber specimens exposed for 20 hours failed the single decon test, a multi-decon test cycle was instituted.

Polycarbonate is impermeable, hence any degradation of the material is a surface phenomenon. During compatibility testing, the surface of the polycarbonate specimen was decontaminated with a cold water-1% detergent solution prior to post weighing of the specimen. The surface of the polycarbonate was adequately decontaminated by this procedure.

#### 2.3.5.4 Multi-Decon Cycle Test

The multi-decon cycle test was limited to butyl rubber specimens. The objective of this test was to determine the ability to decontaminate when the butyl rubber was exposed to the chemical for shorter 2-3 hour time periods. Test sequence was planned upon initially exposing the butyl rubber for a 3-hour period followed by a decon with water and detergent as was similarly done in the single decon test. Any detection of the chemical represented a fail with no further testing conducted.

If no detection was made after the initial 3-hour exposure, eight 2-hour exposures with decontamination washes made between the 2-hour exposures was followed. After the last 2-hour exposure period, any detection of the chemical resulted in a fail and no further testing was done. Failure resulted in assignment into the category of future R&D studies with alternative decontaminating agents.

#### 2.3.5.5 Concentration vs Time Tests

If a butyl specimen failed after 20-hour exposure in the swatch or penetration test, it became scheduled for a concentration versus time test. The objective of this test was to determine at what period of time between three and 20 hours the butyl rubber failed. This test required monitoring between the three and 20-hour period whereas monitoring in the penetration test was conducted at the end of the 3-hour period and the 20-hour

period only. Although it was scheduled that a new butyl rubber specimen be given a 3-hour exposure and decon after conducting the concentration versus time test, this test sequence was not conducted because it was deemed that the chemical had indeed penetrated to the degree that a decontamination problem existed.

#### 2.4 Interim Report - Task IV

MSAR Reports 79-45 and 79-52 were issued in fulfillment of Task IV. Additional comments to MSAR 79-52 were prepared on Task III in a report issued 13 June 1979 and adopted as outlined in 2.3 above.

#### 2.5 Material Compatibility Testing - Task V

Results of material compatibility testing and evaluation are given in Appendix C (test performance rating column). The sealed suit requirement was assigned to 403 chemicals as determined from Levels of Protection, Task I study. Using the Test Program Plan (Test III) as the testing guide, resulted in conducting tests with approximately 235 chemicals. Approximately 163 chemicals were not tested. On a mutually inclusive basis of having no data for either butyl rubber or polycarbonate, 39 of these chemicals were considered for future R&D study (see Section 5.0). Approximately 129 chemicals were not tested but given test performance rating. Rationale used was based upon chemical compatibility data and information pertaining to similar chemical reactivity, water reactivity, insolubility, properties and the like.

##### 2.5.1 Swatch Test Results

Testing was conducted for butyl rubber and polycarbonate against those chemicals where no chemical compatibility data was available. Approximately 113 chemicals were classified for this test. The purpose of this test was to immediately screen out those chemicals which were obviously incompatible with butyl rubber. Figure 4 is a breakdown of the swatch test results. Failure rate was found to be about 60% for butyl rubber and 50% for polycarbonate for those selective chemicals scheduled in this test. Chemicals which passed (40% butyl rubber) went into the penetration test. No additional tests were conducted with polycarbonate.

##### 2.5.2 Penetration Test Results

Penetration tests were conducted with butyl rubber only. This test applied to those chemicals which were classified as being compatible either from available information or from passing the swatch test. The purpose of this test was to further establish resistance of butyl rubber to penetration since little or no data was available for the majority of chemicals, regarding penetration properties.

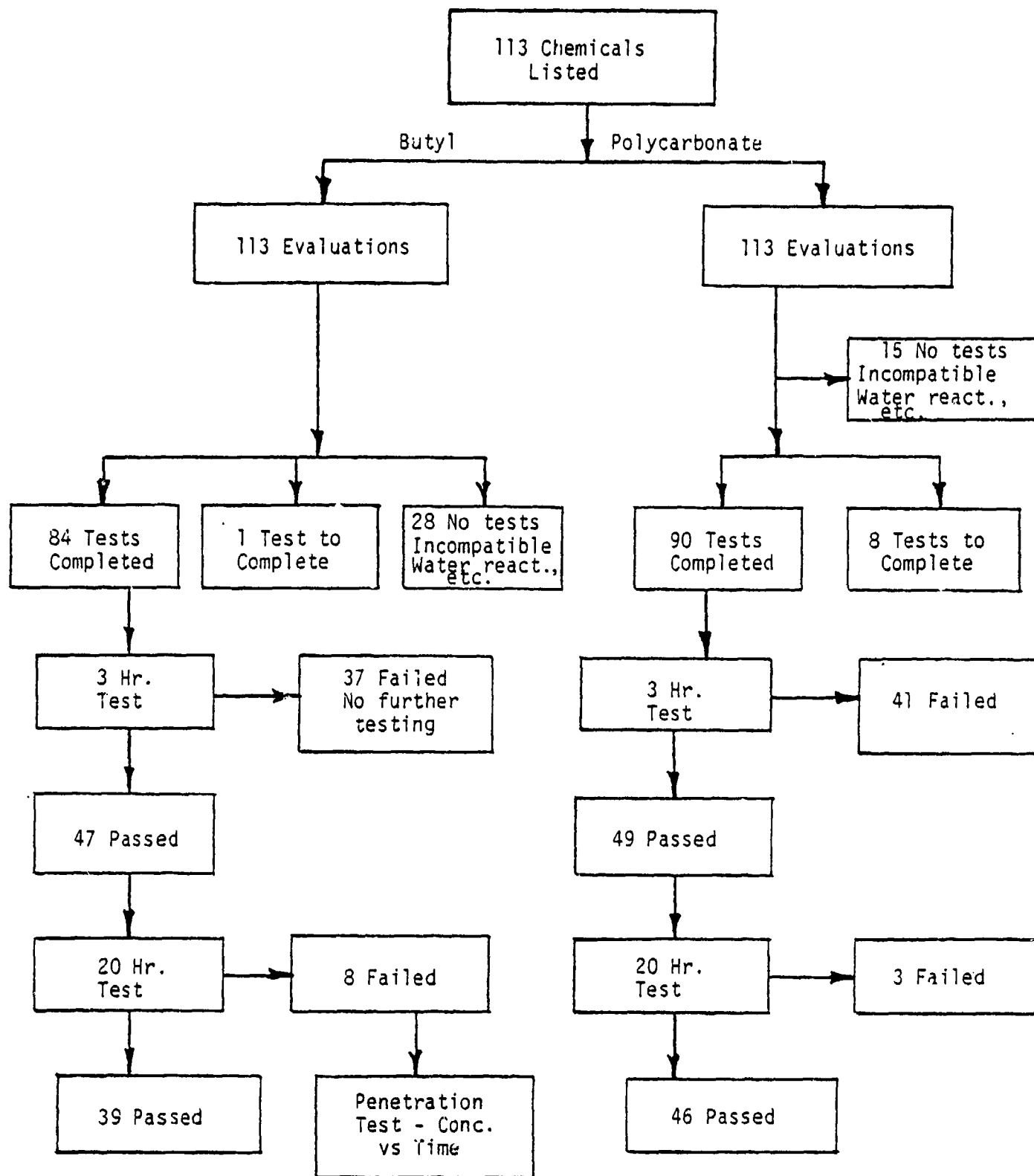


FIGURE 4 - SWATCH TEST DATA BREAKDOWN

Approximately 192 chemicals were used in conducting the penetration test. Basis for failing was any detection of the chemical. Figure 5 summarizes the penetration/decon test results. Approximately 60% passed the 20-hour penetration test. About 35% failed in 3 hours and about 5% failed after 20 hours. There were several cases where butyl rubber was found to be incompatible as evidenced by obvious attack. Chemicals which passed the penetration test were given a single decon test to further confirm test performance rating. Those which failed in 3 hours were considered basically not suitable. Those which failed between 3 and 20 hours were given the concentration versus time test.

#### 2.5.3 Single Decon Test Results

If no penetration was detected after 20 hours of exposure to the chemical, a single decon test (cold water-1% detergent solution) was conducted. A breakdown of results from this test is shown in Figure 5. Approximately 66% passed the single decon test and were given a pass (acceptable) performance rating. The 34% which failed were given the multi-decon test.

#### 2.5.4 Multi-Decon Test Results

The single decon test, which was performed after 20 hours of continuous exposure to the chemical, uncovered a number of chemicals in which decontamination could be a problem. These chemicals were subsequently examined in the multi-decon test which consisted of a series of short term contamination/decontamination cycles. Residual contamination was evaluated after an initial 3-hour exposure and again after a series of eight 2-hour exposures. Decontamination was performed after each exposure.

There were 26 chemicals investigated in the multi-decon test and Table 10 shows the breakdown of test results. Table 11 shows those chemicals which failed and were assigned to future R&D work for alternate decontamination studies. About 45% of the chemicals passed the first 3-hour exposure and 55% failed. Of the chemicals which entered the eight 2-hour portion of the test, a total of 30% passed and 70% failed.

#### 2.5.5 Concentration vs Time Test Results

Swatch test and penetration test results determined the number of concentration versus time tests to conduct based upon failure between 3 and 20 hours. The purpose of this test was to determine the approximate time before breakthrough of the chemical. Appendix C (see table test performance rating column) lists service time/range and no special tabulation of this data is given since there was not a large number of tests conducted.

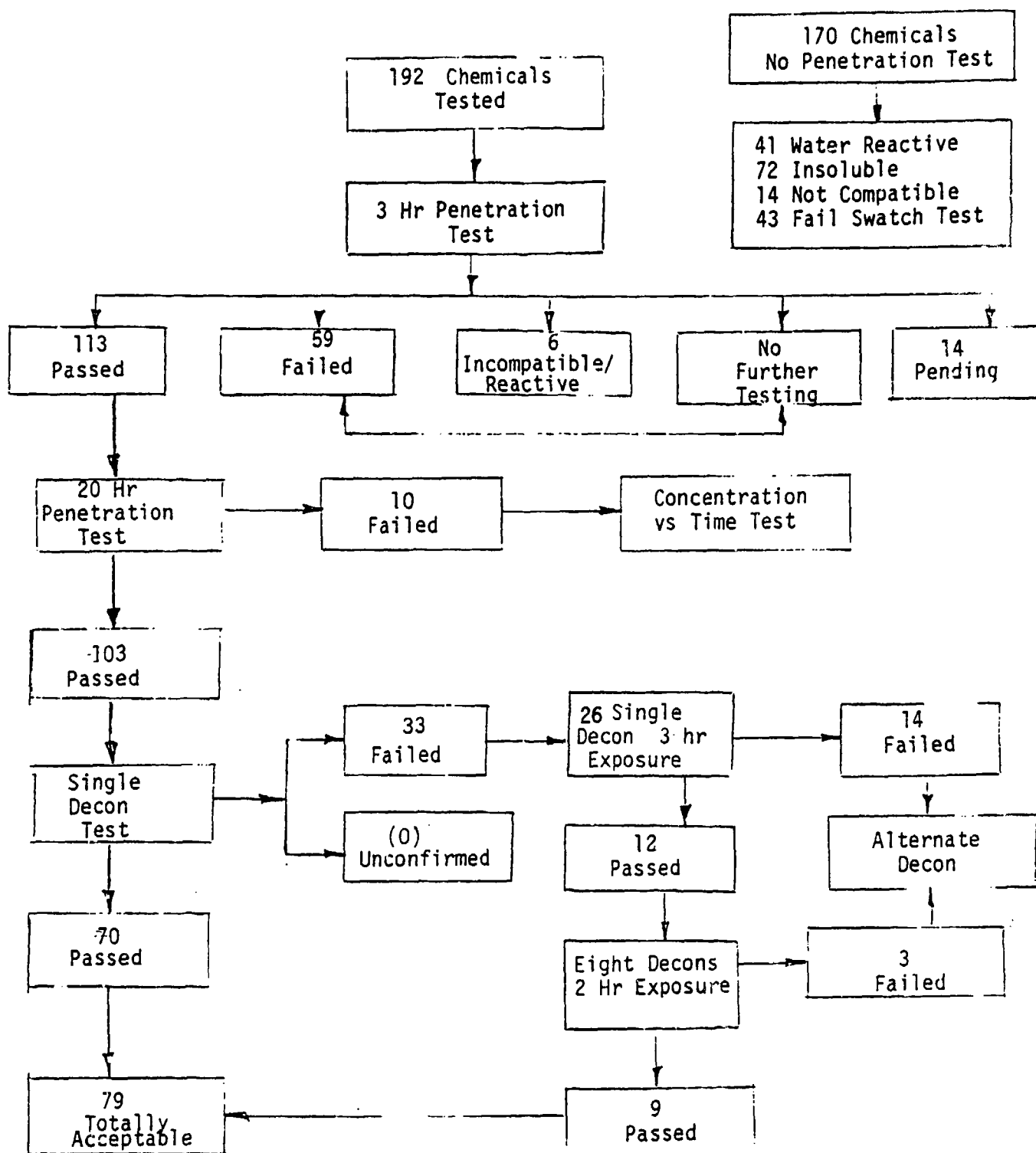


FIGURE 5 - BREAKDOWN OF PENETRATION/DECON TESTS - BUTYL RUBBER

TABLE 10 - DECON CYCLE TEST RESULTS FOR BUTYL RUBBER

CHRIS Code	Chemical Name	Single 3-hour Exposure & Decon	Eight 2-hour Exposures & Decon Cycles*
ARL	Acrolein	Failed, 1 ppm	--
ACR	Acrylic Acid	Passed	Failed, 0.2 ppm
ANL	Aniline	Passed	Failed, 0.5 ppm
BZN	Benzonitrile	Failed, 0.52 ppm	--
BZM	Benzylamine	Passed	Passed
CCT	Creosote	Failed, strong odor	--
DEP	D1-(Ethylhexyl)Phosphoric Acid	Passed	Failed, 0.7 ppm
DDW	2,5 Dimethyl Hexane Dihydroperoxide, Wet	Passed	Passed**
DMH	1,1-Dimethyl Hydrazine	Failed, 0.8 ppm	--
DSF	Dimethyl Sulfate	Passed	Passed** (0.06 ppm)
DIQ	Diquat	Passed	Passed**
EPC	Epichlorohydrin	Failed, 0.6 ppm	--
GCM	Glycidyl Metacrylate	Passed	Passed
IPP	Isopropylamine	Passed	Passed**
MLT	Malathion	Failed, not detected but strong odor	--
MTA	Methylamine	Passed	Passed**
MAA	Methyl Amyl Alcohol	Failed, 0.4 ppm	--
MAN	n-Methylaniline	Failed, 0.6 ppm	--
MIC	Methyl Isobutyl Carbinol	Failed, 0.8 ppm	--
NTB	Nitrobenzene	Failed, 0.8 ppm	--
NPP	2-Nitropropane	Failed, 0.3 ppm	--
PHD	Phosdrin	Passed	Passed**
PII	Propyleneimine, Inhibited	Failed, not detected but strong odor	--
TTP	Tetraethylenepentamine	Passed	Passed
XYL	2,4 Xylenol	Failed, not detected but strong odor	--
HDS	Hydrogen Sulfide	Failed	--

\*Each cycle consists of 2 hr exposure to chemical followed by a cold water detergent one minute wash, then examined after the eighth cycle for residual contamination.

\*\*Slight odor.

TABLE 11- CHEMICALS REQUIRING ALTERNATE DECON INVESTIGATION

<u>CHRIS Code</u>	<u>Chemical Name</u>
ARL	Acrolein
ACR	Acrylic Acid
ANL	Aniline
BZN	Benzonitrile
CCT	Creosote, Coal Tar
DEP	D1-(Ethyl Hexyl) Phosphoric Acid
DMH	1,1-Dimethyl Hydrazine
EPC	Epichlorohydrin
MLT	Malathion
MAA	Methyl Amyl Alcohol
MAN	n-Methylaniline
MIC	Methyl Isobutyl Carbinol
NTB	Nitrobenzene
NPP	2-Nitropropane
PII	Propyleneimine, Inhibited
XYL	2,4-Xylenol

#### 2.5.6 Seam Test Results

Purpose of the seam test was to provide additional information regarding seam design (Table 12). Chemicals tested were based on a selective method and most of the chemicals tested were those which passed the penetration/single decon tests. These tests pointed up that edge effects presented by the seam areas in fabrication of the HCPCO suit can hold up the chemical to a greater degree than smooth fabric presenting no seam edge effects. In regard to penetration, this test verified penetration results obtained with the fabric and also served to show that the seam design and construction was sound.

TABLE 12- BUTYL SEAM TEST RESULTS

<u>CHRIS Code</u>	<u>Chemical Name</u>	<u>Penetration</u>		<u>Single Decon</u>
		<u>3 hr</u>	<u>20 hr</u>	
AAC	Acetic Acid	Pass	Pass	Pass
ACY	Acetone Cyanohydrin	Pass	Pass	Fail (3.2 ppm)
AAM	Acrylamide	Pass	Pass	Pass
ANL	Aniline	Pass	Pass	Fail (8.2 ppm)
CHN	Cyclohexanol	Pass	Pass	Fail (1.4 ppm) Some blister ing on ad- hesive
NTT	p-Nitrotoluene	Pass	Pass	Fail (2.2 ppm)
PHN	Phenol	Pass	Pass	Pass
CBN	4-Chlorobutrylnitric	Pass	Pass	Fail (20 ppm) Some blister ing on ad- hesive
HDZ	Hydrazine	Pass	Pass	Pass

### 3.0 EXPERIMENTAL

The following sections detail the laboratory methods and equipment used to evaluate those chemicals requiring sealed suits. The actual selection of the test methods was strongly influenced by the need to cope with an extremely large number of widely varying chemicals.

#### 3.1 Chemical Sources

The bulk of the chemicals used in the test program were obtained from chemical supply houses. The purity of the chemicals was technical grade or better (>90%) and were used without further purification.

Specialty chemicals including formulations such as agricultural chemicals were obtained from a manufacturer listed in CHRIS for that specific chemical. In cases where the chemical was available in a number of different formulations, the manufacturer was requested to recommend the material most likely to be encountered "outside the fence". The most abundant type of chemicals belonging to the class are the agricultural chemicals; fungicides, herbicides, etc. In most cases, a single working ingredient was found to be available in a number of formulations; i.e., a water wettable powder, an emulsion, or as a solution in an organic solvent. The most common solvents or vehicles used in these preparations are kerosene, xylene, and toluene and all three are incompatible with butyl rubber. Toluene, for example, was examined briefly and was found to dissolve in butyl rubber to the extent of about 0.8 g/g (80% pickup).

CHRIS list chemicals requiring a fully sealed suit and marketed in solvents known to adversely affect butyl or polycarbonate were categorically assigned a "Fail" in the performance rating. These chemicals are identified in Appendix C by the insert "liquid formulation" adjacent to the chemical name.

#### 3.2 Swatch Test

A swatch test was the initial test conducted when chemical resistance data was not available for polycarbonate and butyl rubber. It consisted of exposing polycarbonate and butyl rubber specimens to the chemical and making inspection after a 3-hour and 20-hour period. Overall, one of the primary functions of the swatch test was to eliminate as early as possible the chemicals which grossly attacked the butyl and/or polycarbonate. Specimens were tested in separate containers so that the polycarbonate and butyl rubber specimens were observed individually with chemicals that were liquid or soluble solids dissolved in water. For gases, the specimens were placed in a cell through which the test gas was passed, as described in 3.3.1.

After three hours, the specimens were removed and examined for weight change, dimensional change, or obvious visual damage. This inspection was performed again after 20 hours; and in the case with butyl rubber, additional measurements were made to observe the change in tensile and tear properties in the warp direction of the fabric. A change of 10% in quantitative measurements, obvious visual damage or deterioration was used as fail criteria and no further testing was conducted. Only swatch tests were conducted with polycarbonate. Butyl rubber which passed the swatch test was then given subsequent penetration, single decon, etc. tests.

### 3.2.1 Polycarbonate Swatch Test Specimens

Polycarbonate used in the test was Lexan sheet Grade 9034 material. Size of the specimens was 1 1/4 inch wide x 3 1/2 inch long x 1/6 inch thick. The specimens weighed approximately 5 grams (see Figure 6).

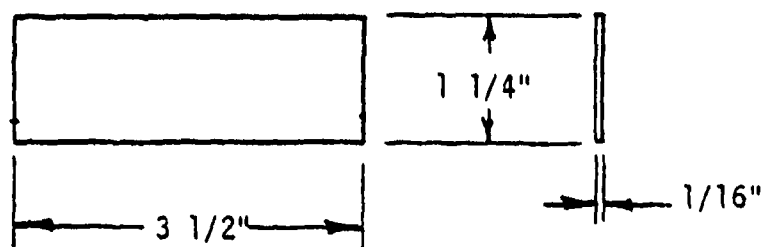
### 3.2.2 Butyl Rubber Swatch Test Specimens

Butyl rubber per MIL-C-12189E obtained from Plymouth Rubber Company was used in all tests in this study. This material is heavyweight (11.0 to 13.5 ounces/square yard). Two specimens 3 inches wide x 6 inches long were cut for each test. After 20 hours of exposure to the chemical, one of the butyl specimens was given a 2-inch long slit and used to measure tear strength and the other one to measure the tensile strength in the warp direction (see Figure 6). The butyl rubber specimens weighed about 4.7 grams. Relative change in tensile and tear strength was obtained by comparing the exposed specimen to specimens which had not been exposed to the chemical.

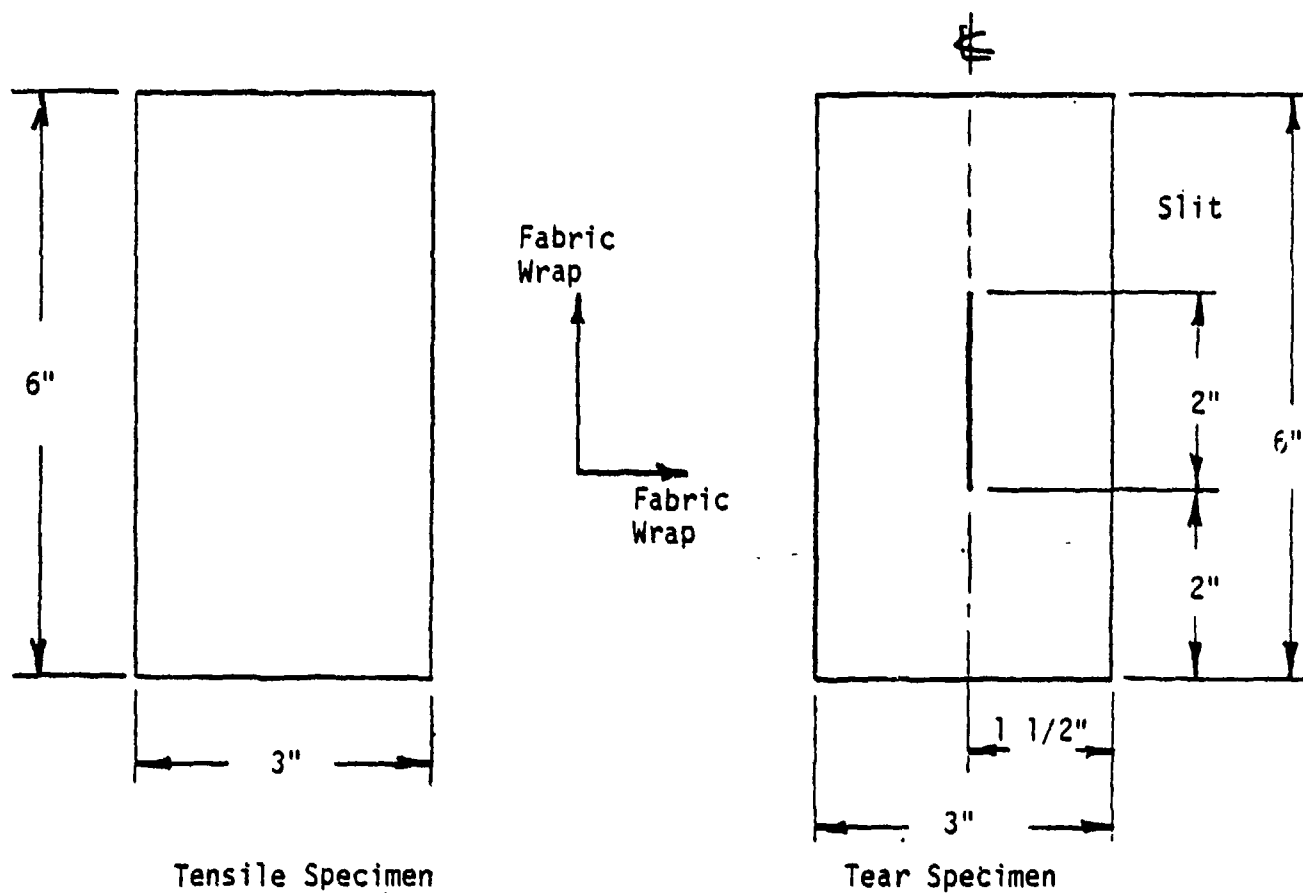
### 3.2.3 Swatch Test Data

Results of the swatch tests are given in Appendix C. Data collected was as follows:

- $W_i$  = Initial weight - polycarbonate and butyl rubber
- $W_3$  = Weight after 3 hours - polycarbonate and butyl rubber
- $W_{20}$  = Weight after 20 hours - polycarbonate and butyl rubber
- $Tens_b$  = Tensile strength - butyl rubber, unexposed blank
- $Tens_{20}$  = Tensile strength after 20 hours - butyl rubber



Polycarbonate Test Specimen  
(Lexan Sheet Grade 9034)



Butyl Rubber (MIL-C-12189E) Test Specimens  
(Heavy Weight 11.0 to 13.5 oz/sq yd)

FIGURE 6 - SWATCH TEST SPECIMENS

$Tear_b$  = Tear strength - butyl rubber, unexposed blank

$Tear_{20}$  = Tear strength after 20 hours - butyl rubber

Equations representing property changes were:

$$\text{Weight change (3 hrs)} = \frac{W_3 - W_i}{W_i} \times 100 = \% \text{ weight change}$$

$$\text{Weight change (20 hrs)} = \frac{W_{20} - W_i}{W_i} \times 100 = \% \text{ weight change}$$

$$\text{Tensile strength change (20 hrs)} = \frac{Tens_{20} - Tens_b}{Tens_b} \times 100 = \% \text{ Tensile Strength Change}$$

$$\text{Tear strength change (20 hrs)} = \frac{Tear_{20} - Tear_b}{Tear_b} \times 100 = \% \text{ Tear Strength Change}$$

### 3.2.4 Swatch Test Instrumentation

Instruments used for swatch test evaluations were:

1. Weight - Scale  
Mettler Model No. H31ARH
2. Strength Properties - Tensile and Tear  
Instron Model 1135 Universal Testing Instrument  
[Set at Separation Speed of 31.7 cm/min  
(12.5 in./min) 225 kg (500 lb) load cell]

### 3.3 Penetration Test

The design of the penetration cell is shown in Figure 7. A number of modifications of this basic design were used in order to cope with the various chemicals. Figure 8 shows a manifold arrangement of cells which permitted four similar tests to be conducted simultaneously. In general, test chemical was applied to one side of the butyl specimen and the subsequent penetrant removed from the underside by an air sweep or by washing.

#### 3.3.1 Cell Design and Modifications

The basic cell was constructed of stainless steel and with the exception of the fittings all components were obtained from a single manufacturer. The design was adopted predominantly because it was simple, easy to operate and was sufficiently flexible to accommodate the wide assortment of different chemicals.

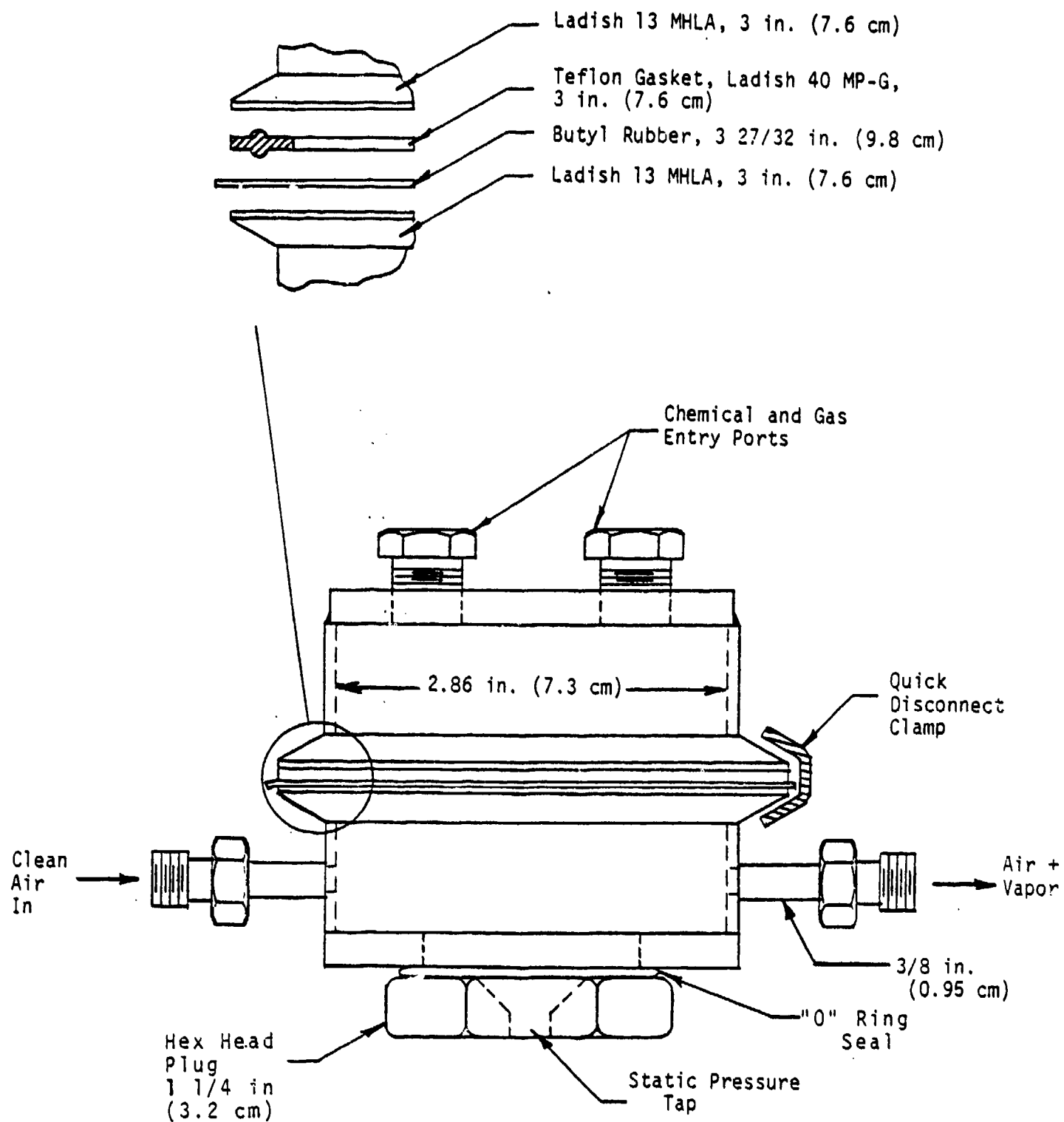


FIGURE 7 - PENETRATION CELL

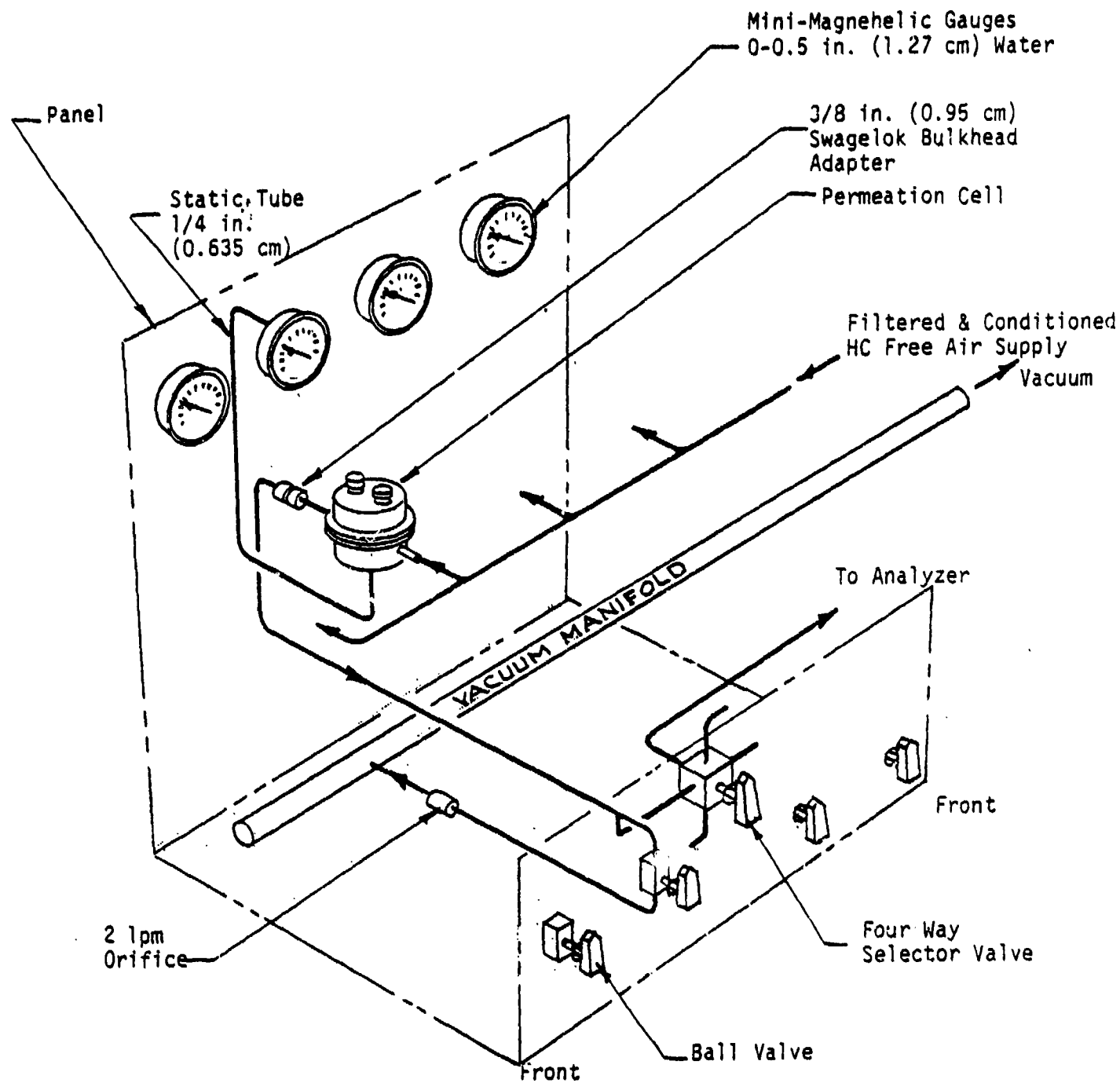


FIGURE 8 - PENETRATION TEST PANEL SCHEMATIC

As is shown in Figure 7, the cell consisted of two similar halves separated by a Teflon "O" ring.

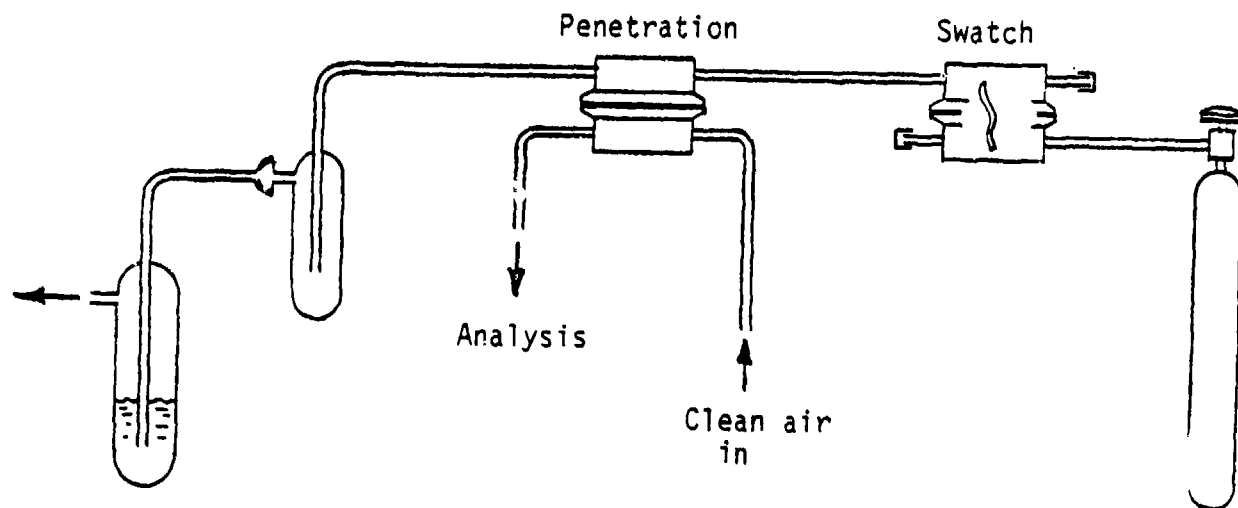
The slightly oversized butyl rubber test specimen was placed directly on the lower flanged cell unit with the "O" ring directly on top. The two halves of the cell were secured by a quick-disconnect clamp.

Leak tightness was assured by the action of the "O" ring which was compressed into corresponding slots cut into the flanges of each half end. The "O" ring when forced into the bottom slot stretched the butyl rubber slightly resulting in the production of a slight strain. When secured in place, the butyl rubber was pulled sufficiently tight to be wrinkle free. The strain on the butyl rubber was not measured but was consistent for all tests. The chemically exposed surface was 41.2 sq cm (6.42 sq in.).

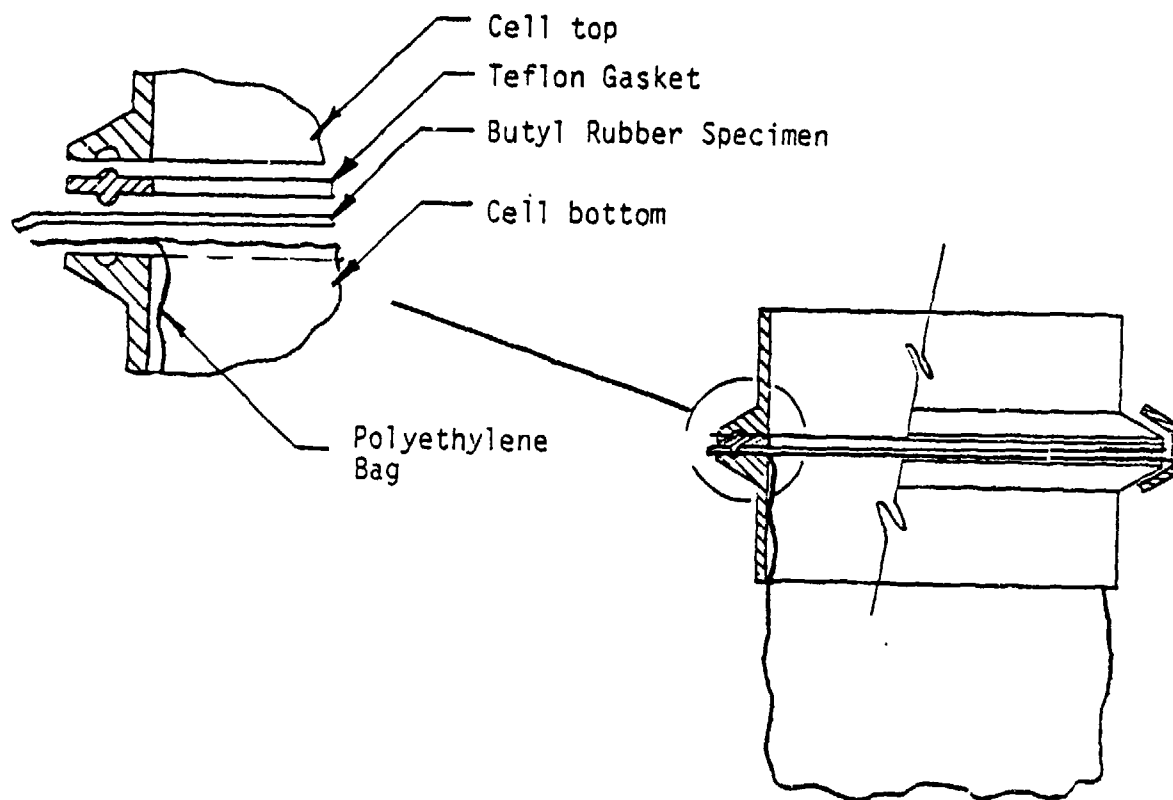
The cell used in studying the penetration from gases consisted of combining two of the lower half cell units shown in Figure 7. An overall gas test system is shown in Figure 9(a). The particular arrangement was employed in cases where only limited supply of the test gas was available. In this case, several tests were conducted at the same time in order to conserve challenge chemical. Tests with gases were conducted with a continuous flow of test gas passing above the butyl specimen. Flow of test gas was usually 1 to 5 cc/min.

Figure 9(b) shows the design of the cell used to study penetration of inorganic materials, specifically penetrant chemicals which might become contaminated by laboratory or other extraneous contaminants. As is noted in Figure 9(b), the bottom half of the cell is open and a flexible polyethylene container was sealed under the butyl specimen. With this design, the penetrant emerging from the underside of the butyl specimen was automatically sealed off from the walls of the cells and from other sources of contamination. Subsequent operations consisted of merely cutting the plastic bag and exposing the underside of the butyl specimen.

Recovery of penetrant was achieved either by continuously purging the underside of the test specimen with a flow of hydrocarbon free air or by vigorously rubbing and washing the penetrant free. Penetration by simple organic liquids was determined by sweeping the underside with a flow of 2 lpm of processed air cleaned by passage through a carbon bed followed in line by a bed of heated hopcalite. The resultant hydrocarbon content of the sweep air was maintained at <2.0 ppm.



a. Arrangement for Swatch and Penetration Test with Gases



b. Arrangement for Penetration Test in Contaminant Free Environment

FIGURE 9 - MODIFICATIONS OF PENETRATION CELL FOR GASES AND CONTAMINANT FREE SERVICE

Penetration by metal salts solution was determined by vigorously swabbing the underside of the butyl using 10 cc of water and processed glass wool or a flat Teflon rod.

### 3.3.2 Typical Test Operation

Butyl rubber test specimens consisted of circular discs measuring 9.76 cm (3.84 in.) diameter overall.

For simple organic liquids, the test specimen was installed in the cell as shown in Figure 7. The completed cell was then placed on the four unit module as shown in Figure 8. A vacuum pump aspirated a flow of 2 lpm of clean air through the lower portion of the cell. A reading of the Magnehelic gage insured that a significant negative pressure relative to the atmosphere was not developing. Normal vacuum developed as a result of aspirating the air flow was limited to  $<0.13$  cm ( $<0.05$  in.) water. At selected intervals, the clean air sweep passing through the chemically free cell was diverted to the analyzer. The cell was considered clean when the analyzer showed no difference in quality between the clean air at its source and the clean air which passed through the cell. At this point, the test was initiated by the addition of 10 cc of chemical to the upper portion of the cell. The cell was continuously purged by the 2 lpm flow until the test was terminated (20 hrs). As a minimum, analysis of the quantity of penetrant in the purge air was performed at the end of 3 hours and again at 20 hours.

Penetration by inorganic salt solutions was studied in the open-end cell unit shown in Figure 9(b). A quantity of 10 cc of a saturated water solution of the salt was applied to the top of the butyl specimen. No air purge was used and the test apparatus was stored at room temperature for 20 hours. After this period of time, the chemical was removed, the cell was inverted and the underside of the butyl was exposed and subsequently scrubbed/washed with 10 cc of distilled water. Collected washings were subsequently analyzed for selected metal ions in components.

Methods of detection are summarized in Section 3.8.

### 3.4 Single Decon Tests

When a butyl rubber specimen passed the 20-hour penetration test, the effectiveness to decontaminate the chemical from the butyl rubber was examined. The single decon test consisted of removing the butyl rubber from the penetration test apparatus, wiping and rinsing off excess chemical. It was then placed in a wire basket suspended from the lid of a household blender containing one liter of cold water with a 1% concentration of powder detergent. The blender was operated for one minute.

The specimen was removed and rinsed with cold water and excess water removed with an absorbent paper towel. The specimens were checked for decontamination of the organic or inorganic chemicals as discussed below.

#### 3.4.1 Organic Chemicals

Effectiveness of the single decon test was examined by placing the butyl rubber in the penetration test cell. The chemically exposed side was mounted as the underside where it was swept with clean air flowing into the total hydrocarbon analyzer. Any increase in the total hydrocarbon concentration above the clean air reading indicated residual chemical contamination and ineffective decontamination. Ineffective decontamination then required that a new butyl rubber specimen be given a multiple decontamination test.

#### 3.4.2 Inorganic Chemicals

Effectiveness of the single decon test was examined by placing the butyl rubber specimen on a petrie dish. A 10 cc syringe was filled with distilled water and discharged onto the chemically exposed side of the butyl specimen. A Teflon spatula was scraped over the butyl rubber and distilled water was used to extract any residual chemical remaining. The distilled water/solution was decanted from the petrie dish into a test tube and analysis made of the water in the manner described in 3.8 to determine if the single decon test was effective. Any detection of the test chemical required that a new butyl rubber specimen be given a multiple decontamination test.

#### 3.4.3 Single Decon Instrumentation

Instrumentation and procedures used in the single decon test consisted of those discussed in the penetration test.

#### 3.5 Multi-Decon Test

When the butyl rubber specimens exposed to the chemical for 20 hours failed after a single decon, a multi-decon test was conducted. As discussed previously, this test consisted of exposing a new butyl rubber specimen for three hours followed by a single cold water detergent wash. Examination for residual chemical was made and if chemical was present future R&D alternate decontamination studies were deemed necessary. If no detection was made after three hours, eight 2-hour exposures and decons were performed and after the eighth cycle examination made for presence of residual chemical. Similarly, as after the initial 3-hour exposure, detection of the chemical placed it in the category of future R&D alternate decontamination studies. If the chemical was not detected after the exposure cycles, butyl

rubber was given a pass performance rating. If any contaminant was detected after the initial 3-hour exposure or after the eight 2-hour exposures, the butyl rubber was assigned a fail performance rating (see Appendix C).

#### 3.5.1 Butyl Rubber Test Specimen

Butyl rubber specimens (MIL-C-12189E) were cut identically to those used in the penetration test.

#### 3.5.2 Test Procedure

Apparatus and analytical procedures were the same as for the penetration test. Chemical was placed on the butyl rubber for a three hour period. The butyl rubber was removed from the test cell and then given a single one minute decon wash and dried. It was then examined for any trace of the chemical. If the chemical was detected, it was assigned in future R&D alternate decontamination studies. If no chemical was detected, the butyl rubber was exposed to the chemical for eight 2-hour exposure cycles with a decon wash given between each cycle. After the eighth cycle, the butyl rubber was examined again for any trace of the chemical.

#### 3.6 Concentration vs Time Tests

Butyl rubber failing between three and 20 hours was given the concentration versus time test. Butyl rubber specimens, apparatus and test procedures were the same as followed in the penetration tests with the exception that additional monitoring was done to determine breakthrough time period.

#### 3.7 Seam Test

The purpose of this test was to investigate edge effects and soundness of the seam design used in the HCPCO suit construction.

##### 3.7.1 Seam Test Specimen

Typical seams used in the HCPCO suit were obtained from ILC Dover, Fredrica, Delaware. The test specimen was circular and cut to the size used in the penetration test. It was cut so the seam was centerline in the penetration cell. Seam construction is a lap fold sewn with a 2.54 cm (1 inch) butyl strip glued (Bostic Co. 1177) to both the inner and outer surface of the butyl rubber sections it forms.

##### 3.7.2 Seam Test Chemicals

Seam test chemicals were chosen primarily from those chemicals which had been tested in the penetration/single decon tests and found acceptable.

### 3.7.3 Test Procedure

The seam specimen was placed in the cells used for the penetration test. Because these seamed specimens were thicker than the single layer butyl rubber fabric used in the penetration test, additional takeup to achieve a seal required the use of a silicone rubber gasket rather than a Teflon gasket. Since the silicone rubber gasket is less chemically inert than the Teflon, it was placed under the butyl rubber seamed specimen to prevent it from contacting the chemical. Otherwise, apparatus and procedure remained the same as followed in the penetration test; the specimen being examined after three hours and 20 hour time period.

### 3.8 Summary of Analytical Methods

Table 13 summarizes the analytical methods used in this program. For practical reasons, the number of different procedures were held to a minimum.

The lower limits of detection listed in Table 13 are a reasonable estimate of the minimum quantity of chemical that could be detected under the test conditions. Invariably, trace background contamination was present in which case the quantity of chemical which could be detected above the background level was approximately twice the suggested or ideal lower limit.

#### 3.8.1 Detection of Organic Vapors

Analysis of organic vapors in the effluent purge gas was performed exclusively by a MSA Hydrocarbon Analyzer. This instrument offers an extended range with the bulk of the work performed on the 0-12 ppm full scale range. The instrument was calibrated with 5.0 ppm methane gas mixture supplied by Matheson, East Rutherford, NJ.

#### 3.8.2 Detection of Metal Salts

A Model 303 Perkin Elmer Atomic Absorption Spectrophotometer was used to analyze metal ions dissolved in the specimen wash liquid.

Penetration and decon effectiveness were determined by using a control or blank and also included the generation of a recovery factor. In short, washing an uncontaminated test specimen was performed in order to determine background contamination that could be present. To a second specimen, a known quantity of a corresponding metal salt in solution was added and allowed to dry for 20 hours. Usually, the added spike totalled 50  $\mu$ g of the metal ion. The specimen with the added contamination was subsequently washed and the washings processed along with the washings of test material. The amount recovered was usually about 30 to 50%

TABLE 13 - SUMMARY OF ANALYTICAL METHODS

Basic Method Employed	Chemical Detected	Lower Limits of Detection (ppm)*
Hydrocarbon Analyzer	Organic Vapor	0.05
Atomic Adsorption	Metal ions	
	Cd <sup>++</sup>	0.04
	Cr(III)	0.15
	Cr(VI)	0.15
	Na <sup>+</sup>	0.015
	K <sup>+</sup>	0.05
	Pb <sup>++</sup>	0.07
	Hg(II)	11.0
	Hg(II)	11.0
	Zn <sup>++</sup>	0.025
	Li <sup>+</sup>	0.04
	Ni <sup>++</sup>	0.15
Specific Ion Electrode	Selected non-metal ions	
	NH <sub>4</sub> <sup>+</sup>	0.2
	F <sup>-</sup>	0.2
Detector Tubes	Selected Gases/Vapors	
	SO <sub>2</sub>	<2.5
	H <sub>2</sub> S	<1-2
	Cl <sub>2</sub>	<0.5

\*Present in the 2 lpm air sweep or in 10 cc of wash liquid.

of the initial added quantity. In all cases, the wash procedure was found effective for metal ion recovery when used at the 50  $\mu$ g level of contamination.

### 3.8.3 Detection of Nonmetal Ion

Ammonium and fluoride in wash liquid were determined using specific ion electrodes obtained from Fisher Scientific. Recovery factors and trace contamination levels (blanks) were established as described above.

### 3.8.4 Use of Detector Tubes

The detector tubes were obtained from MSA. These tubes are certified to offer a minimum of 35% accuracy at the concentrations listed in Table 13. When the tubes are used for qualitative purposes the lower limits of detection can be reduced by at least a factor of three. In the laboratory, the detector tubes were used for both quantitative and qualitative purposes.

#### 4.0 DISCUSSION OF RESULTS

Absence of complete toxicological data was the primary obstacle in establishing Levels of Protection categories for all of the 985 chemicals. A sealed suit requirement was designated for 403 chemicals. There were 327 chemicals in this list of 403 chemicals which were based upon Sax's Toxic Rating Guide and 76 chemicals which were based upon other standards or best judgment. In the total of 985 chemicals reviewed there were 45 chemicals in which no level of protection assignment was made. The breakdown of the Level of Protection results were as follows:

<u>Requirement</u> <u>(Level of Protection)</u>	<u>No. Chemicals</u>
Sealed Suit	403
Nonsealed Suit	436
Fire Suit	15
Goggles, gloves, hard- hat and footwear	86
Unassigned	<u>45</u>
Total	985

Assignment of level of protection was given for 940 of the 985 chemicals and 45 chemicals remain for further definition pending additional toxicological information. Assignment of 403 chemicals to the category of sealed suit became the basis of material compatibility testing investigation.

Survey of commercially available protection clothing revealed that a variety of sealed, nonsealed and other protective apparel are available. Being less sophisticated and not subject to special military type specifications, the commercial type protective clothing is much less expensive than the HCPCO sealed suit. Commercially available protective clothing material is primarily elastomeric polyvinyl chloride, polyvinyl alcohol, butyl rubber, neoprene rubber, urethane, polyethylene, etc., some of which are sandwiched over nylon or cotton inner fabrics. Even considering this variety of materials relative to the listing of CHRIS chemicals, lack of chemical resistance data obscured a complete alternate material substitution listing. This also applied to head protection materials such as clear polyvinyl chloride, polycarbonate, cellulose acetate and acrylic most commonly employed. Because of its chemical inertness, Teflon promises the most universal chemical resistance; however, state-of-the-art fabrication has negated its applicability because of its inherent inertness properties. A somewhat clear Teflon material is available and can be considered for a visor although

it does not possess as good visual properties as clear polycarbonate. Teflon yarn is available for sewing seams. Bonding patches over the seams would be required to cover holes left from sewing.

Because of insufficient chemical compatibility data on butyl rubber and polycarbonate used in the HCPCO suit, a testing program was required. In addition, testing was required to further explore penetration and decontamination properties since little or no such data was available for the majority of the chemicals. Consequently, a test program plan had to be devised to establish an overall performance rating since chemical resistance data was insufficient for butyl rubber but judged adequate for polycarbonate. A test program plan was developed in this effort. This plan represents a model of the experimental process one can employ in evaluating the material protective properties against a spilled chemical contaminant. The output of the experimental model served as a guide to ascertain suitability of butyl rubber for use as a sealed suit.

The plan included provisions for dealing with certain chemicals which, because of practical or technical reasons, could not be processed in a straightforward manner. Along these lines certain classes of chemicals were excluded from the experimental portion of the test plan. These classes were: water reactive, solid insolubles and chemical formulations containing one or more components known to be material incompatible.

The threat of chemicals which are both solid and insoluble in water is mainly particulate and a well-made suit would normally offer adequate protection. The performance rating assigned in this case was the generally accepted literature designation. Chemicals which were formulated as mixtures containing a solvent or vehicle known to adversely affect the test materials were failed. This was a frequent occurrence with agricultural type formulations, e.g., chlordane in hexane and the specific ingredient or solvent was suitably identified.

Realistically, a spill of a water reactive compound can be encountered in the field as a mixture ranging in composition from 100% pure compound to 100% reaction products. A closer examination of the chemicals for sealed suit use showed the predominant reaction product to be a strong mineral acid, notably HCl. Selected studies showed HCl solution at concentrations of even 10% caused serious damage to the structural strength of the butyl. In one case, no penetration was observed from the parent or unreacted compound. The addition of water caused a dramatic increase in temperature ( $\Delta T = 25^{\circ}\text{C}$ ) and resulted in immediate chemical penetration. As a consequence, all water reactive chemicals yielding strong mineral acids were categorically failed. Water reactive materials yielding less reactive products were assigned the literature designation with this rating limited to the parent or unreacted chemical.

Basically, five different types of experimental tests were conducted in the test plan sequence. The tests and test functions were:

<u>Test Type</u>	<u>Test Function</u>
Swatch	Establish basic compatibility data for chemical where no data was available (applicable to both butyl rubber and polycarbonate).
Penetration	Evaluate butyl rubber as an impermeable protective barrier.
Single Decon	Isolated chemicals in which no decontamination problems exist after 20 hours chemical contact.
Multi-Decon	A less demanding test revealing decontamination effectiveness for a shorter or single mission 2-3 hour exposure period to the chemical.
Concentration vs Time	Establish use limits of butyl rubber relative to service time.

To provide supplementary data, seam testing was conducted to show soundness of the HCPCO suit seams and any limitation of decontaminating presented by edge/adhesive effects.

Appendix C lists a test performance rating of polycarbonate and butyl rubber for 403 chemicals requiring a sealed suit. A summary of test performance rating results were as follows:

#### Polycarbonate

Pass (20 hr contact)	211
Pass (>3 hr <20 hr)	1
[Pass] (Parent compound, water reactive)	29
Fail (<3 hr contact)	90
[Fail] (Parent compound, water reactive)	29
No data	<u>43</u>
Total	403

### Butyl Rubber

Pass (totally acceptable)	142
Pass (>3 hr <20 hr)	5
[Pass] (Parent compound, water reactive)	6
Fail (unacceptable)	183
[Fail] (Parent compound, water reactive)	4
No data	<u>63</u>
Total	403

Both polycarbonate and butyl rubber offered excellent protection against all metal ions and neutral salts. This fact tends to exaggerate the applicability of these two plastics. Table 14 lists the overall performance of these materials against specific classes of chemicals as categorized by CHRIS. The findings suggest that both polycarbonate and butyl rubber are somewhat weak against the more abundantly produced organic chemicals. On the basis of test results wherein chemical compatibility for both butyl rubber and polycarbonate exists, 130 chemicals can be handled with the HCPCO suit. Acceptability for use mandates that both materials be compatible with the chemical of interest.

It is logical, especially in view of the high failure rate, to examine the viability of the test methods. The impact of specific experimental tests on the number of fail ratings is shown below:

<u>Type of Test</u>	<u>Test Condition</u>	<u>% Failed*</u>	<u>% of All Failures</u>
Penetration	3 hr contact	35*	78.5
Penetration	20 hr contact	9.4	--
Single Decon	20 hr contact	33	--
Multi Decon	3 hr contact	52	17.5
Multi Decon	8 2-hr contact	25	4

\*Based on total number entering test

The bulk of the failures were recorded during the first three hours of the penetration tests, and this suggests an inherent weakness in the butyl. Conducting the test for 20 hours did not result in a significant increase in failure rate. It is interesting to note that one out of three chemicals could not be removed from butyl rubber by a simple water/soap wash when the contact time was 20 hours. Approximately half these chemicals could not be removed when the contact time was reduced to 3 hours. Overall, the various decontamination tests were responsible for only 16 failures or a total of 21.5% of all failure ratings.

TABLE 14 - CHEMICAL RESISTANCE BY CLASS

<u>Chemical Groupings</u>	<u>Performance Rating</u>	
	<u>Polycarbonate</u>	<u>Butyl</u>
1. Nonoxidizing Mineral Acids	Pass	Fail
2. Sulfuric Acids Spent 98% or less	Fail	Fail
3. Nitric Acid	Fail	Fail
4. Organic Acid	Pass	Pass
5. Caustics	Fail	Pass
6. Ammonia	Pass	Pass
7. Aliphatic Amines	Fail	Fail/Pass
8. Aromatic Amines	Fail	Fail
9. Organic Anhydrides	Pass	Pass
10. Isocyanates	Pass	Pass
11. Vinyl Acetate	Pass	Fail
12. Acrylates	Fail/Pass	Fail
13. Substituted Alkyls	Pass/Fail	Fail
14. Alkylene Oxide	Pass	Fail
15. Epichlorohydrin	Pass	Fail
16. Ketones	Pass	Fail
17. Aldehydes	Fail/Pass	Fail
18. Alcohols, Glycols	Pass	Pass
19. Phenols and Cresols	Pass/Fail	Fail/Pass
20. Caprolactum Solution	Pass	Pass
21. Aromatic Hydrocarbons	Fail	Fail
22. Vinyl Halides	Pass/Fail	Fail
23. Halogenated Hydrocarbons	Fail/Pass	Fail/Pass
24. Nitriles	Pass	Fail
25. Carbon Disulfide	Fail	Fail
26. Ethers	Fail	Fail
27. Nitrocompounds	Fail/Pass	Fail

Certainly, the adoption of "detectable quantity" for the above tests impacted directly on the relative number of pass or fail ratings. Undoubtedly detection levels for the tests could be lowered by the use of more sophisticated and involved methods of enrichment and detection which presumably would have resulted in a higher failure rate. This can be countered somewhat by the fact that the final disposition of the chemical either as a penetrant or as a residual following decon is uncertain. Realistically, the Strike Team does not experience a chronic exposure to the same chemical as would be the case for an industrial worker. Overall, the method and procedure used in the experimental program reflects a certain middle-of-the-road approach.

This study provided an improved and protective base for recommending levels of protection and protective equipment needed by Strike Team personnel. Because of the large number of chemicals, the different types of chemicals and the lack of toxicological data, recommendations could not be formulated for all 985 chemicals on the CHRIS list. Additional R&D is required, and specific recommendations are presented in Section 5.0.

## 5.0 RECOMMENDATIONS

### 5.1 General Comments

Butyl rubber and polycarbonate materials are used in the HCPCO sealed suit. A preliminary literature survey on chemical compatibility of these materials indicated a higher degree of compatibility than actually found in the testing programs. This was because the testing program was more extensive in scope and was used to evaluate not only compatibility but also penetration and decontamination. For example, butyl rubber was found to be about 38% compatible from the experimental testing whereas the indicated chemical compatibility from preliminary literature survey indicated much higher chemical compatibility.

Combining compatibility test result data for both butyl rubber and polycarbonate materials jointly further reduces the compatibility of the HCPCO suit ensemble. Mutual combination of compatibility data for these materials indicates the suit to be satisfactory for only 130 (32%) of the 403 chemicals requiring use of a sealed suit.

Alternate candidate materials would be expected to have a lower acceptability rate than what might be expected from literature and manufacturers data, also. However, alternate material investigation is viewed as necessary because of the limitations of butyl rubber and polycarbonate used in the HCPCO suit.

### 5.2 Future R&D Effort (Task VI)

Future R&D efforts are recommended as follows:

1. Alternative material investigation for butyl rubber and polycarbonate used in the HCPCO suit.
2. Additional testing of those chemicals which were not evaluated because of water reactivity, insolubility, unavailability coupled with the absence of pertinent literature data.
3. Determination of levels of protection for those chemicals with insufficient toxicological data. Sealed suit level of protection assignment will require additional butyl rubber and polycarbonate testing.
4. Assessment of alternate decon agents and methods.

### 5.2.1 Alternative Material Investigation

Appendix A lists some alternative materials for cases where butyl rubber and polycarbonate were not compatible or when data did not exist. This data served only as a guideline to establish compatible or incompatible status; the more rigorous testing conducted in Task V (Material Compatibility Testing) showed that an unacceptable status could develop even when compatibility was indicated. Table 15 was prepared to list those chemicals and alternative materials that can be considered for future R&D investigation. Available literature was used to select alternative materials. Thus, it is a preliminary guideline for materials which must be further verified by testing. Table 15 also shows the need for alternative materials because of the weakness of butyl rubber and polycarbonate when their performance is compared with the variety of chemical groups involved. There are cases in which the chemical or chemical group in which a material choice could not be determined. In some cases where chemical compatibility data indicates good or excellent resistance, disappointing results were obtained in the more rigorous tests conducted in this program.

### 5.2.2 Additional Testing of Butyl Rubber and Polycarbonate

There were instances where no compatibility data was generated relative to the testing program plan. This was because of insoluble solids, lack of availability and insufficient information to relate it with a similar chemical reactivity group (see Table 16).

On a practical basis, solid chemicals would be encountered as dusts or general particulate matter. The insoluble nature of these chemicals suggests a certain chemical inertness although this argument is not sufficiently convincing to suggest that no attack (solid-solid reaction) with the protective ensemble can occur.

Some decisions on compatibility were based on the by-product materials, primarily acids formed by the reaction of the parent product with water. In some cases, the data indicated that butyl rubber and/or polycarbonate were compatible with the parent compound but not with the reaction products. Additional testing of water reactive compounds and reaction products is recommended.

### 5.2.3 Levels of Protection

Table 7 lists 44 chemicals for which assignment of levels or protection data were not available. It is possible that additional toxicological information may be forthcoming from chemical manufacturers and other sources. In general, however, toxicological studies are long term activities requiring many years of study before

TABLE 15 - POTENTIAL ALTERNATIVE MATERIALS FOR INVESTIGATION AS PER  
CHRIS CHEMICAL REACTIVITY GROUPING

Chemical Groupings	Available Data		Hood Material			Alternative Material Guide			
	Polycarbonate	Butyl	Acetate	Vinyl	Others	Vinyl	Polyethylene	Neoprene	Others
1. Non-Oxidizing Mineral Acids Hydrochloric, Hydrofluoric Acid	Pass	Fail	NA	NA	--	X	--	--	Chlorinated Polyethylene
2. Sulfuric Acid Spent & 98% or less	Fail	Fail	--	X	--	X	--	X	--
3. Nitric Acid	Fail	Fail	--	X	--	X	--	--	--
4. Organic Acid Acetic Acrylic Acid Oxalic Acid	Pass Pass Pass	Pass 3 hr (Pass)	NA NA NA	NA NA NA	NA NA NA	NA -- X	NA -- X	NA -- --	NA Chlorinated Polyethylene Chlorinated Polyethylene
5. Caustics Potassium & Sodium Hydroxide	Fail	Pass	--	X	--	NA	NA	NA	--
6. Ammonia	(Pass)	Pass	NA	NA	NA	NA	NA	NA	NA
7. Aliphatic Amines Butyl Amine Cyclohexylamine Dibutylamine Di-n-propylamine Ethyl Amine Propylamine Tetraethylenepentamine Triethylamine Triethylenetetramine	Fail Fail Fail Fail Fail Fail Fail Fail Fail	Fail Fail Fail Fail Fail Fail Pass Fail Pass							Chlorinated Polyethylene Chlorinated Polyethylene Chlorinated Polyethylene
8. Aromatic Amines Aniline	Fail	Fail	--	--	Polyethylene Polypropylene	--	X	--	
9. Organic Anhydrides Acetic Anhydride	Pass	Pass	NA	NA	NA	NA	NA	NA	NA
10. Isocyanates Diphenyl Methane Diisocyanate	Pass	Pass	NA	NA	NA	NA	NA	NA	NA
11. Vinyl Acetate Vinyl Acetate, Inhibited	(Pass)	(Fail)	NA	NA	NA	--	--	--	Chlorinated Polyethylene
12. Acrylates Ethyl Acrylate (Inhibited) 2-Ethylhexyl Acrylate (Inhibited) Ethyl Methacrylate (Inhibited) Methyl Acrylate (Inhibited) Methyl Methacrylate (Inhibited)	(Fail) (Fail) (Fail) (Pass) (Fail)	Fail Fail Fail Fail Fail							Chlorinated Polyethylene Chlorinated Polyethylene NA
13. Substituted Alkyls Acrylonitrile (Inhibited) Allyl Alcohol Allyl Chloride	(Pass) (Pr) (Fail)	Fail Fail Fail	NA NA NA	NA NA NA	NA NA NA	-- -- --	-- -- --	-- -- --	Chlorinated Polyethylene Chlorinated Polyethylene
14. Alkene Oxide Butylene Oxide	(Pass)	Fail	NA	NA	NA				
15. Epichlorohydrin Epichlorohydrin	(Pass)	Fail	NA	NA	NA	--	X	X	--
16. Ketones Mesityl Oxide	(Pass)	Fail	NA	NA	NA	--	--	--	Ethylene Propylene Chlorinated Polyethylene
17. Aldehydes Acetaldehyde Acrolein Butraldehyde Decaldehyde Ethylhexaldehyde Formaldehyde Glutaldehyde Solution	(Fail) (Pass) Fail Fail Fail Fail Pass Pass	Fail Fail Fail Fail Fail Fail Fail Fail	-- NA NA NA NA NA NA NA	-- NA NA NA NA NA NA NA	Ethyl Cellulose NA NA NA NA NA NA NA	-- -- -- -- -- -- X X	-- -- -- -- -- -- -- --	X X -- -- -- -- -- --	Silicone -- -- -- -- -- -- Nylon, Viton
18. Alcohols, Glycols Cyclohexanol	Pass	Pass	NA	NA	NA	NA	NA	NA	NA
19. Phenols & Cresols Carbolic Oil Creosote, Coal Tar Monyl Phenol Phenol	(Pass) Pass Pass Pass (Fail)	Fail Fail(D) Pass Pass Fail	NA NA NA NA NA	NA NA NA NA NA	NA NA NA NA NA	NA NA NA NA NA	NA NA NA NA NA	NA NA NA NA NA	NA NA NA NA Chlorinated Polyethylene
20. Caprolactum Solution Caprolactum Solution	(Pass)	(Pass)	NA	NA	NA	NA	NA	NA	NA
21. Aromatic Hydrocarbons Benzene Cumene	Fail	Fail			Acetal Polyvinyl Acetate	--	--	--	Viton
22. Vinyl Halides Vinyl Chloride Vinylidene Chloride (Inhibited)	(Pass) Fail	(Fail) Fail	NA NA	NA NA	NA NA				
23. Halogenated Hydrocarbons Chloroform Dichlorobenzene 1,1, Dichloroethane Dichloroethyl Ether Ethyl Chloride Ethylene Dibromide Ethylene Dichloride Methyl Bromide 1,1,2,2-Tetrachloroethane	Fail Fail Fail Fail Fail Fail Fail Fail Fail	Fail Fail Fail Fail Fail Fail Fail Fail Fail							Nylon Viton --
24. Nitriles Acetonitrile Adiponitrile	(Pass) (Pass)	> 20 hr Fail	NA NA	NA NA	NA NA				
25. Carbon Disulfide Carbon Disulfide	Fail	Fail	--	--	Chlorinated Polyether				Nylon Viton
26. Ethers Tetrahydrofuran	(Fail)	Fail							
27. Nitrocompounds (mono-) Nitrobenzene 1 or 2-Nitropropane Nitrotoluene	(Fail) (Pass) Fail	Fail Fail Fail	NA NA NA	NA NA NA	NA NA NA	-- -- --	-- -- --	-- -- --	Polyvinyl Alcohol

NA - not applicable

TABLE 16 - SEALED SUIT CHEMICALS FOR FUTURE R&amp;D EVALUATION

CHRIS Code	Chemical Name	Untested Status	Performance Data Sought	
			Polycarbonate	Butyl Rubber
BDE	Bisphenol A Diglycidyl Ether	Unavailable	X	X
CAS	Calcium Arsenite	Insoluble	X	X
DBT	O-Chloronitrobenzene	Insoluble	X	X
CMC	Chromyl Chloride	Water React.	X	-
COU	Coumaphos	Insoluble	X	X
DZP	Di-(p-Chlorobenzoyl) Peroxide	Unavailable	X	X
DPT	Dibutyl Phenol	Insoluble	X	X
DIU	Diuron	Insoluble	-	X
DNZ	Dinitrobenzene	Insoluble	X	X
ESF	Endosulfane	Insoluble	X	X
ETI	Ethylene Imine	Water React.	-	X
FFX	Ferric Fluoride	Water React.	X	X
FSA	Fluosulfonic Acid	Water React.	X	-
KPE	Kepone	Insoluble	X	X
LSA	Lead Stearate	Insoluble	X	X
MLH	Maleic Hydrazide	Insoluble	X	X
MRT	Mercuric Thiocyanate	Insoluble	X	X
MPK	Methylisopropenyl Ketone	Unavailable	X	X
MCT	Methylcyclopentadienyl Manganese Tricarbonyl	Unavailable	X	X
MRX	Mirex	Insoluble	X	X
NLD	Naled	Insoluble	X	X
NKD	Nickel Hydroxide	Insoluble	X	X
NTL	Nitralin	Insoluble	X	X
NAA	Nitrotriacetic Acid, Salts	Insoluble	X	X
NAL	4-Nitroaniline	Insoluble	X	X
OXA	Oxalic Acid	Analytical	-	X
PPP	Phosphorous Pentasulfide	Water React.	-	X
PCB	Polychlorinated Biphenyl	Unavailable	-	X
PBO	Potassium Binoxalate	Unavailable	-	X
SML	Sodium Methylate	Water React.	-	X
SCM	Strontium Chromate	Insoluble	X	X
STR	Strychnine	Insoluble	X	X
TED	Tetramethyldithiopyrophosphate	Insoluble	X	X
TEP	Tetraethylpyrophosphate	Slow Water React.	-	X
TTT	Titanium Tetrachloride	Water React.	X	-
TCA	2,4,5-Trichlorophenoxyacetic Acid	Insoluble	X	X
TPO	Tris(Azidiny)Phosphine Oxide	Unavailable	X	X
TDT	Toluene 2,4-Diisocyanate	Slow Water React.	-	X
URP	Uranium Peroxide	Insoluble	X	X
UAN	Uranium Nitrate	Analytical	X	X
URS	Uranium Sulfate	Analytical	X	X
VSF	Vanadyl Sulfate	Analytical	-	X
VCM	Vinyl Chloride	Unavailable	-	X
ZEC	Zectran	Insoluble	X	X
ZCN	Zinc Cyanide	Insoluble	X	X
ZCT	Zirconium Tetrachloride	Water React.	X	-

recommended exposure levels are established. Therefore, until the data becomes available, fully encapsulating suits should be used for spills of these 44 chemicals. This dictates the need for additional materials compatibility studies for these chemicals.

#### 5.2.4 Alternative Decon Agents

The decon method employed in this work was a cold water, detergent solution wash. Chemicals ineffectively decontaminated are listed in Table 11. Alternate decon materials and methods suggested for future R&D investigation are:

1. Use of hot water and strong detergent solution wash cycle.
2. Investigate longer and multiple wash cycle times.
3. Use of decon agents other than the detergent:
  - (a) Acid type chemicals; use 5% basic solution wash cycle.
  - (b) Basic type chemical; use 5% weak acid wash cycle.
4. Specialized techniques such as steaming, vacuuming, autoclaving, extended airing, etc.

An acceptable decon agent is one which does not in itself present a toxic hazard or else additional deconning would be necessary. An acceptable decon agent and method must be inexpensive and implemented without logistic problems. An examination of the general class of chemicals found to require additional decon studies shows they are closely related to chemical classes which were ultimately found to cause a breakthrough such as aldehydes, amines, aromatic types, etc. This can be interpreted that these chemicals have penetrated somewhat into the matrix of the butyl. Depth of penetration apparently is not severe; however, experience suggests that these chemicals would eventually defy rather mild methods of deconning.

Depending upon the chemical and its penetration into the matrix of the fabric, there is the possibility that deconning may be obtained after an extended time in the open air.

No edge effects resulted with the circular butyl specimens decontaminated because the periphery of the specimen was outside the chemically exposed surface. In conducting seam tests, edge effects were present and this presents another matter. Some chemicals which were effectively decontaminated from the butyl

rubber with no edge effects but which were found to fail with butyl rubber specimens having seamed edge/adhesive present are:

1. ACY - Acetone Cyanohydrin
2. CHN - Cyclohexanol
3. NTT - p-Nitrotoluene
4. CBN - 4-Chlorobutrylnitrile

Although these seamed specimens passed the penetration test, edge effects can present other decon considerations to reckon with. This suggests that perhaps future testing be more expediently conducted including seam portions of the fabric.

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APPENDIX A  
LEVELS OF PROTECTION

(References listed by number in the tables  
are included in the Bibliography)

Legend:

C	- CHRIS Code
CN	- Chemical Name
S	- State
WR	- Water Reactive
F	- Flammable
VP	- Vapor Pressure (mm Hg @ 37.8°C)
TWA	- Time Weighted Average
STEL	- Short Term Exposure Limit
IN	- Inhalation
SA	- Skin Absorption
IR	- Irritant
PF	- Particulate Filter
CC	- Chemical Canister
AS	- Air Supply
SS	- Sealed Suit
NS	- Nonsealed Suit
B	- Butyl
P	- Polycarbonate
DNA	- Data Not Available
( )	- TLV or Hazard Rating Shown in Parentheses Based on Decomposition Products

## INTRODUCTION

Strike Team personnel could be exposed to hazardous chemicals in liquid, solid and/or vapor states during cleanup of spills. Protective clothing and respiratory protection could be required, and the degree of protection will depend upon the chemical involved and the nature of that chemical. Since Strike Team members could be in direct contact with hazardous liquids, solids and/or vapors during initial entry into a spill area, a conservative or "safe side" approach was used in recommending levels of protection. As cleanup progresses and the degree of hazard is better characterized, the On-Site Coordinator may decide that a lesser level of protection is acceptable.

Attempts were made to assign levels of protection for each of the 985 chemicals listed in CHRIS. A toxic hazard rating developed by Sax (Sax, 1975) was used to estimate the acute exposure effects due to inhalation, skin absorption or irritation (Table A-1). These estimates were used in recommending the type of respiratory protection and clothing required for the various chemicals (Table A-2). The compatibility of butyl rubber and polycarbonate, the materials used in the Hazardous Chemical Protective Clothing Outfit (HCPCO), with the chemicals were determined from a literature search.

This Appendix contains information which will be useful for decision making by the On-Site Coordinator. A few examples are given to assist the user in interpreting the information in the Appendix.

Acetone is a liquid (S) at normal temperatures and is not water reactive (WR). It is flammable (F) and has a moderate vapor pressure (VP) of 37 mm Hg. The permissible 8 hr exposure level (TWA) is 1000 ppm, and the short term exposure level (STEL) is 1250 ppm. It poses a moderate inhalation (IN) and skin absorption (SA) hazard but is not particularly irritating (IR). A chemical cartridge respirator (CC) or an air supply (AS) is recommended, but a sealed suit is not required (NS). Butyl rubber (B) is compatible with acetone, but polycarbonate (P) may have a limited lifetime before clouding occurs.

Anhydrous ammonia is a gas (S) at normal temperatures and is water reactive (WR). It is flammable (F) and exhibits an extremely high vapor pressure (VP). The permissible 8 hr exposure level (TWA) is 25 ppm and the short term exposure

TABLE A-1 - TOXIC HAZARD RATINGS ACCORDING TO SAX

<u>Rating</u>	<u>Effect</u>	<u>Comments</u>
0	None	(a) No harm under any conditions; (b) Harmful only under unusual conditions or overwhelming dosage.
1	Slight	Causes readily reversible changes which disappear after end of exposure.
2	Moderate	May involve both irreversible and reversible changes not severe enough to cause death or permanent injury.
3	High	May cause death or permanent injury after very short exposure to small quantities.
U	Unknown	No information on humans considered valid by authors.

TABLE A-2 - GUIDELINES FOR SELECTION OF PERSONAL PROTECTION EQUIPMENT

Toxicity Rating	Mode of Entry	Response			
		Gas & Liquids	Solids		
		<u>Respiratory</u>	<u>Clothing</u>	<u>Respiratory</u>	<u>Clothing</u>
0	Inhalation Skin Absorption Irritation	None required " "	None required " "	None required " "	None required " "
1	Inhalation Skin Absorption Irritation	Chemical filter <sup>2</sup> ---- ----	---- Nonsealed Nonsealed	Particulate ---- ----	---- Nonsealed Nonsealed
2	Inhalation Skin Absorption Irritation	Chemical filter or air supply <sup>2</sup> ---- ----	---- Nonsealed Nonsealed	Particulate & chemical filter ---- ----	---- Nonsealed Nonsealed
3	Inhalation Skin Absorption Irritation	Air supply <sup>3</sup> ---- ----	---- FES <sup>1</sup> FES <sup>1</sup>	Air supply <sup>3</sup> ---- ----	---- FES <sup>1</sup> FES <sup>1</sup>

<sup>1</sup>Fully encapsulating sealed suit indicates need for air supply

<sup>2</sup>Contaminants in gaseous form at STP indicates need for air supply

<sup>3</sup>Carcinogens indicate need for air supply

limit (STEL) is 35 ppm. It is a severe inhalation hazard (IN) and irritant (IR). An air supply or self-contained breathing apparatus (AS) and a sealed suit (SS) are recommended. Both butyl rubber and polycarbonate are compatible with the chemical.

Ammonia bisulfite is a solid (S) at normal temperatures and is water reactive (WR). No data were available on the flammability or vapor pressure of the chemical. The permissible 8 hr exposure level (TWA) is 5 ppm based on the chemical-water reaction product of  $\text{SO}_2$ . Sulfur dioxide is a severe inhalation (IN) hazard and irritant (IR). An air supply or self-contained breathing apparatus (AS) and a sealed suit (SS) are recommended. No data were available on the compatibility of butyl rubber and polycarbonate with sodium bisulfite, however these materials are compatible with  $\text{SO}_2$ .

It was, of course, impossible to assign levels of protection for all 985 of the chemicals on the CHRIS list. Additional research is being conducted to determine the hazards posed by the various chemicals, the required levels of protection and the type of materials to be used in spill clean up. As this information becomes available, it is anticipated that the information contained herein will be updated. Meanwhile, On-Site Coordinators and Strike Team personnel should find this information valuable and should become acquainted with the usage of this information.

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SW-TOXIC HAZARD RATING			LEVELS OF PROTECTION: RESPIRATORY CLOTHING				MATERIAL COMPATIBILITY [10]		NOTES	
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B		P
AAD	Acetaldehyde	L	No	Yes	>760	100	150	3	-	3	3	-	X	X	-	Yes	No (ACE)	[12]
AAC	Acetic Acid	L	No	Yes	31.0	10	15	2	-	3	3	-	X	X	-	Yes	Yes	
ACA	Acetic Anhydride	L	Yes	Yes	12.0	5	-	2	-	3	3	-	X	X	-	Yes	Yes	[12]
ACT	Acetone	L	No	Yes	37.0	1000	1250	2	2	1	-	-	X	-	-	Yes	No (ACR)	
ACY	Acetone Cyanohydrin	L	No	Yes	0.7	(10)	-	(3)	(3)	(2)	(2)	-	X	X	-	Yes	Yes	Toxic rating & TLV as HCN [8]
ATN	Acetonitrile	L	No	Yes	260	40	-	(3)	(3)	(1)	(1)	-	X	X	-	Yes	Yes	Toxic rating as CN [8]
ACP	Acetophenone	L	No	Yes	1.0	200	-	U	U	U	U	-	X	-	X	Yes	Yes	Animal experiments indicate low toxicity [8]
ABM	Acetyl Bromide	L	Yes	Yes	210	(10)	(25)	3	-	3	3	-	X	X	-	Yes	Yes	TLV as acetic acid [8]
ACC	Acetyl Chloride	L	Yes	Yes	470	1	-	3	-	3	3	-	X	X	-	Yes	No	
APB	Acetyl Peroxide Solution	L	Yes	Yes	~10	DNA	-	2	-	2	2	-	X	X	-	Yes	Yes	
ATA	Acetyl Acetone	L	No	Yes	18	DNA	-	2	-	1	1	-	X	X	-	Yes	No	
ACE	Acetylene	G	No	Yes	>760	5000	-	2	0	0	0	-	X	X	-	Yes	Yes	
ACD	Acridene	S	No	Yes	<0.01	0.2*	-	2	-	2	2	-	X	X	-	Yes	Yes	
ARL	Acrolein	L	No	Yes	686	0.1	0.3	3	2	2	2	-	X	X	-	Yes	Yes	
AAH	Acrylamide	S	No	Yes	DNA	0.3*	0.6*	3	2	3	3	-	X	X	-	Yes	No	
ACR	Acrylic Acid	L	No	Yes	11	DNA	-	3	-	3	3	-	X	X	-	Yes	Yes	
ACN	Acrylonitrile	L	No	Yes	390	20	30	(3)	(3)	(1)	(1)	-	X	X	-	Yes	Yes	toxic rating as CN [8]
ADA	Adipic Acid	S	No	Yes	<0.01	-	-	U	U	U	U	-	-	-	-	Yes	Yes	Low toxicity food additive [5]
ADM	Adiponitrile	L	No	Yes	<0.25	18	0.75*	3	3	-	-	-	X	X	-	Yes	Yes	Insecticide carcinogen
ALD	Aldrin	S	No	No	<0.25	0.25*	-	3	2	-	-	-	-	-	-	Yes	Yes	
ABS	Alkylbenzenesulfonic Acid	L	No	No	<0.3	0.017	-	-	-	1	1	-	X	X	-	Yes	Yes	
ALA	Allyl Alcohol	L	No	Yes	55	2	4	3	2	2	2	-	X	X	-	Yes	Yes	
ABR	Allyl Bromide	L	No	Yes	~200	-	-	2	2	2	2	-	X	X	-	Yes	Yes	
ALC	Allyl Chloride	L	No	Yes	~600	1	2	3	2	3	3	-	X	X	-	Yes	Yes	
ATC	Allyl Trichlorosilane	L	Yes	Yes	36	(5)	-	(3)	-	(3)	(3)	-	X	X	-	Yes	No	Toxic rating as silanes, TLV as HCl [8]
ACF	Allyl Chloroformate	L	Yes	Yes	~600	-	-	3	-	3	3	-	X	X	-	Yes	No	
ACL	Aluminum Chloride	S	Yes	No	<0.25	(5)	-	3	-	3	3	-	X	X	-	Yes	Yes	TLV as HCl [8]
ALF	Aluminum Fluoride	S	No	No	<0.25	(2.5)*	-	(3)	-	(3)	(3)	-	X	X	-	Yes	Yes	TLV & toxic rating as fluoride
ALM	Aluminum Nitrate	S	No	No	<0.25	(1)*	-	(2)	-	(3)	(3)	-	X	X	-	Yes	Yes	Toxic rating as nitrates [8]
ALN	Aluminum Sulfate	S	No	No	<0.25	-	-	U	U	U	U	-	-	-	-	Yes	Yes	Toxic rating & TLV as sulfuric acids [8]
AEA	n-Aminoethylethanolamine	L	No	Yes	0.04	-	-	U	U	U	U	-	-	-	-	Yes	No	Experiments indicate low toxicity [8]
AWA	Ammonia, Anhydrous	G	Yes	Yes	>760	25	35	3	-	3	3	-	X	X	-	Yes	Yes	
AAT	Ammonium Acetate	S	No	Yes	<0.25	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Heat preservative [5]
ABZ	Ammonium Benzoate	S	No	No	<0.25	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Food preservative [5]
ABC	Ammonium Bicarbonate	S	No	No	<0.25	-	-	-	-	-	-	-	-	-	-	Yes	Yes	Monotonic [5]
ABF	Ammonium Bifluoride	S	No	No	<0.25	(2.5)*	-	(3)	-	(3)	(3)	-	X	X	-	Yes	Yes	Toxic rating as fluorides [8]
ASU	Ammonium Bisulfite	S	Yes	-	(5)	-	-	(3)	-	(3)	(3)	-	X	X	-	-	-	TLV & toxic rating as SO2
ANB	Ammonium Bromide	S	No	No	<0.1	DNA	-	(2)	-	(1)	(1)	-	X	X	-	-	-	Toxic rating as bromides
ACH	Ammonium Carbamate	S	No	-	decomp. in air	(25)	35	(3)	-	(3)	(3)	-	X	X	-	-	-	TLV & toxic rating as NH3
ACB	Ammonium Carbonate	S	No	No	0.25	(25)	35	1	-	1	1	-	-	-	-	Yes	Yes	TLV as NH3

C	CN	S	WR	F	VP	TLV (ppm or mg/m <sup>3</sup> )*		SAV-TOXIC HAZARD RATING				LEVELS OF PROTECTION					MATERIAL COMPATIBILITY [10]			NOTES
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY			CLOTHING	B	P			
												CC	AS	SS						
AMC	Ammonium Chloride	S	No	No	<0.25	10*	20*	-	-	-	X	-	-	-	-	Yes	Yes	Carcinogen, TLV & toxic rating as CrO <sub>3</sub> [8] Low toxicity [5] Toxic rating & TLV as CrO <sub>3</sub> [8] Toxic rating as fluoride [8] TLV & toxic rating as formic acid [8] Nontoxic [5]		
ACH	Ammonium Chromate	S	No	-	-	(0.1)*	-	(3)	-	(3)	-	-	X	X	-	Yes	Yes			
ACI	Ammonium Citrate	S	No	No	<0.25	DNA	-	(3)	-	(3)	X	-	-	-	-	Yes	Yes			
AMD	Ammonium Dichromate	S	No	Yes	<0.25	(0.1)*	-	-	-	-	-	-	-	-	-	Yes	Yes			
AFB	Ammonium Fluoborate	S	No	-	Sublimes	DNA	-	(3)	-	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as fluoride [8] Toxic rating as fluoride [8] TLV & toxic rating as formic acid [8] Nontoxic [5]		
AFR	Ammonium Fluoride	S	No	No	<0.25	(2.5)*	-	(3)	-	(2)	X	-	-	-	-	Yes	Yes			
AFM	Ammonium Formate	S	No	Yes	<0.25	(5)	-	(2)	-	(2)	X	-	-	-	-	Yes	Yes			
AGC	Ammonium Gluconate	S	No	No	<0.25	DNA	-	-	-	-	X	-	-	-	-	Yes	Yes			
AMH	Ammonium Hydroxide (28% Sol'n.)	L	No	No	-	1	(1)	2	-	2	-	X	X	-	X	Yes	No(PVC)	TLV & toxic rating as phosphine Toxic rating as iodide [8] Nontoxic [10] No toxicity data [5-8] Toxic rating as ammonium nitrate [8]		
RHP	Ammonium Hypophosphate	S	No	No	<0.25	(0.3)	-	(3)	-	(2)	X	-	-	-	-	Yes	Yes			
AID	Ammonium Iodide	S	No	No	<0.25	DNA	-	(2)	-	-	X	-	-	-	-	Yes	Yes			
ALT	Ammonium Lactate	S/L	No	No	<0.25	DNA	-	-	-	-	-	-	-	-	-	Yes	Yes			
ALS	Ammonium Lauryl Sulfate	L	No	No	0.2	DNA	-	2	-	2	X	X	-	-	-	Yes	Yes	No toxicity data Toxic rating as ammonium nitrate Nontoxic [10] Toxic rating as oxalates [8] Toxic rating for boron compounds [8] Toxic rating for perchlorates [8] Low toxicity [5]		
AMP	Ammonium Molybdate	S	No	No	<0.25	5*	-	1	-	1	X	-	-	-	-	Yes	Yes			
AMN	Ammonium Nitrate	S	No	No	<0.25	DNA	-	1	-	(1)	X	-	-	-	-	Yes	Yes			
ANP	Ammonium Nitrate-Phosphate Mix	S	No	No	<0.25	DNA	-	(1)	-	(1)	X	-	-	-	-	Yes	Yes			
ANS	Ammonium Nitrate-Sulfate Mix	S	No	No	<0.25	DNA	-	(1)	-	(1)	X	-	-	-	-	Yes	Yes	Toxic rating for boron compounds [8] Toxic rating for perchlorates [8] Low toxicity [5]		
ANU	Ammonium Nitrate-Urea Solution	L	No	No	<0.25	DNA	-	(1)	-	(1)	X	-	-	-	-	Yes	Yes			
AOL	Ammonium Oleate	S	No	Yes	<0.25	DNA	-	-	-	(3)	-	-	X	X	-	Yes	Yes			
AOX	Ammonium Oxalate	S	No	No	<0.25	DNA	-	-	-	-	-	-	-	-	-	Yes	Yes			
APB	Ammonium Pentaborate	S	No	No	<0.25	10*	-	(2)	-	(2)	X	X	-	-	-	Yes	Yes	Toxic rating as fluoride & fluosilicates [8] Low toxicity [5] Animal experiments indicate low toxicity [5] TLV & toxic rating as H <sub>2</sub> S [8] TLV & toxic rating as NH <sub>4</sub> OH [8] No toxic data Low acute toxicity [8]		
AMP	Ammonium Perchlorate	S	No	No	<0.25	DNA	-	(2)	-	(2)	X	X	-	-	-	Yes	Yes			
APE	Ammonium Persulfate	S	No	Yes	<0.25	DNA	-	1	-	U	X	-	-	-	-	Yes	Yes			
APP	Ammonium Phosphate	S	No	No	<0.25	DNA	-	U	-	U	X	-	-	-	-	Yes	Yes			
ASL	Ammonium Silicofluoride	S	No	No	<0.25	2.4*	-	(3)	-	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as fluoride & fluosilicates [8] Low toxicity [5] Animal experiments indicate low toxicity [5] TLV & toxic rating as H <sub>2</sub> S [8] TLV & toxic rating as NH <sub>4</sub> OH [8] No toxic data Low acute toxicity [8]		
AMR	Ammonium Stearate	S	No	Yes	<0.25	DNA	-	-	-	-	X	-	-	-	-	Yes	Yes			
ASM	Ammonium Sulfamate	S	No	No	<0.25	10*	-	-	-	-	X	-	-	-	-	Yes	Yes			
AMS	Ammonium Sulfate	S	No	No	0.25	DNA	-	1	-	1	X	-	-	-	-	Yes	Yes			
ASF	Ammonium Sulfide	L	No	Yes	~ 721	(10)	(15)	(3)	-	(3)	-	-	X	X	-	Yes	Yes	TLV & toxic rating as H <sub>2</sub> S [8] TLV & toxic rating as NH <sub>4</sub> OH [8] No toxic data Low acute toxicity [8]		
AME	Ammonium Sulfite	S	No	No	<0.25	(1)	-	(2)	-	(2)	X	-	-	-	-	Yes	Yes			
ATR	Ammonium Tartrate	S	No	No	<0.25	DNA	-	-	-	-	-	-	-	-	-	Yes	Yes			
AMT	Ammonium Thiocyanate	S	No	No	<0.25	DNA	-	-	-	-	-	-	-	-	-	Yes	Yes			
ATF	Ammonium Thiosulfate	S	No	No	<0.25	DNA	-	1	-	1	X	-	-	-	-	Yes	Yes	Narcotic in high concentration [5] Toxic rating as acetone Moderately toxic [5]		
AML	n-Amyl Acetate	L	No	Yes	<10.9	100	105	2	-	1	-	X	X	-	-	Yes	No			
AAH	n-Amyl Alcohol	L	No	Yes	6.8	100	-	2	-	2	-	X	X	-	-	Yes	Yes			
AMY	n-Amyl Chloride	L	No	Yes	> 15	DNA	-	U	-	U	-	-	-	-	-	Yes	No			
AMN	n-Amyl Mercaptan	L	No	Yes	26.2	DNA	-	1	-	1	-	-	-	-	-	Yes	No	Toxic rating as acetone Moderately toxic [5]		
AMK	n-Amyl Methyl Ketone	L	No	Yes	4.0	100	-	(2)	-	(1)	-	X	X	-	-	Yes	No			
ANI	n-Amyl Nitrite	L	No	Yes	~ 19	DNA	-	2	-	2	-	X	X	-	-	Yes	No			
ANT	n-Amyl Nitrate	L	No	Yes	~ 8	DNA	-	2	-	2	-	X	X	-	-	Yes	Yes			

C	CN	MR	F	VP	TLV (PPM OR MG/M3)*		SAX-TOXIC HAZARD RATING			LEVELS OF PROTECTION CLOTHING					MATERIAL COMPATIBILITY (10)		NOTES	
					TWA	STEL	IN	SA	IR	PF	RESPIRATORY			B	P			
											CC	AS	SS			NS		
ATS	n-Butylchlorosilane	Yes	Yes	2	(5)		(3)	-	(3)	-	-	-	X	X	-	Yes	No	TLV & toxic rating as HC [8]
ANL	Aniline	No	Yes	5	(5)		(3)	-	(3)	-	-	-	X	X	-	Yes	No	TLV as HC
ASC	Anisoyl Chloride	Yes	Yes	0.15	(5)		(3)	-	(3)	-	-	-	X	X	-	Yes	No	Skin carcinogen
ATH	Anthracene	No	Yes	<0.001	1*		-	-	-	-	-	-	X	X	-	Yes	Yes	
APF	Antimony Pentachloride	Yes	No	4.5	0.5*(Sb)		3	-	3	-	-	-	X	X	-	Yes	No(vinyl)	[6]
APT	Antimony Pentachloride	Yes	No	16	0.5*(Sb)		3	-	3	-	-	-	X	X	-	Yes	Yes	
ATP	Antimony Potassium Tartrate	No	No	<0.25	0.5*(Sb)		3	-	-	-	-	-	X	X	-	Yes	Yes	
ATB	Antimony Tribromide	Yes	-	-	0.5*(Sb)		3	-	-	1	-	-	X	X	-	Yes	Yes	
ATM	Antimony Trichloride	Yes	No	<0.6	0.5*(Sb)		3	-	3	-	-	-	X	X	-	Yes	Yes	Strong irritant, eyes & skin, rashes
ATT	Antimony Trifluoride	No	No	<<0.25	0.5*(Sb)		3	-	3	-	-	-	X	X	-	Yes	Yes	
ATX	Antimony Trioxide	No	No	<<0.25	0.5*(Sb)		(3)	-	(2)	-	-	-	X	X	-	Yes	Yes	Toxic rating as arsenic
ASA	Arsenic Acid	No	No	DNA	0.5*(Sb)		(3)	-	(2)	-	-	-	X	X	-	Yes	Yes	
APC	Arsenic Pentoxide	Yes	-	DNA	0.25*		(3)	-	(2)	-	-	-	X	X	-	Yes	No(PVC)	[12] Arsenic acid forms with water contact
ARD	Arsenic Sulfide(DI)	Yes	Yes	DNA	0.5*(As)		(3)	-	(2)	-	-	-	X	X	-	Yes	Yes	Treat like SO2 when water contacts
AST	Arsenic Trichloride	Yes	No	23	0.35*		(3)	-	(2)	-	-	-	X	X	-	Yes	Yes	High toxicity, decomposes in air
ATO	Arsenic Trioxide	No	No	<<0.25	0.5*(As)		(3)	-	(2)	-	-	-	X	X	-	Yes	Yes	
ART	Arsenic Trisulfide	Yes	No	<<0.25	0.5*(As)		(3)	-	(2)	-	-	-	X	X	-	Yes	Yes	
ASP	Asphalt	No	Yes	<<0.25	5*	10*	-	-	(2)	-	-	-	X	X	-	Yes	Yes	Use same TLV as for asphalt
ARE	Asphalt Blending Stocks, Roofers Flux	No	Yes	DNA	DNA		-	-	(2)	-	-	-	X	X	-	Yes	Yes	Use same TLV as for asphalt
ASR	Asphalt Blending Stocks, Straight Run Residue	No	Yes	DNA	DNA		-	-	(2)	-	-	-	X	X	-	Yes	Yes	
ATX	Atrazine	No	No	DNA	10*		2	-	-	-	X	-	-	-	-	Yes	Yes	Moderately toxic, herbicide
AM	Azinphosmethyl	No	Yes	<<0.25	0.2*		3	-	(1)	-	-	-	X	X	-	Yes	Yes	Cholinesterase inhibitor
BBC	Barium Carbonate	No	No	<<0.25	0.5*(Ba)		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	Toxic rating as barium
BCR	Barium Chlorate	No	No	<<0.25	0.5*(Ba)		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BCY	Barium Cyanide	No	-	-	0.5*(Ba)		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	Toxic rating as CN
BNT	Barium Nitrate	No	Yes	<<0.25	0.5*(Ba)		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BPC	Barium Perchlorate	No	No	<<0.25	0.5*(Ba)		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BPM	Barium Permanganate	No	Yes	<<0.25	0.5*(Ba)		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BPO	Barium Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-	No	No	Carcinogen [11]
BHC	Benzene Hexachloride	No	No	<<0.01	0.5*		2	-	1	-	-	-	X	X	-	Yes	Yes	May be skin absorbed
BPD	Benzene Peroxide	No	No	<<0.25	0.066		(3)	-	(1)	-	-	-	X	X	-	Yes	Yes	
BzD	Benzaldehyde	No	Yes	2.0	DNA		(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as aldehydes [8]
BMZ	Benzene	No	Yes	165	10		2	-	2	-	-	-	X	X	-			

C	CN	S	MR	F	VP	TLV (ppm or mg/m <sup>3</sup> )		SAF-TOXIC (HAZARD) RATING					LEVELS OF PROTECTION					MATERIAL COMPATIBILITY (100)			NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	MS	B	P				
BCL BCF BAP BZA	Benzyl Chloride Benzyl Chloroformate Benzyl n-Butyl Phthalate Benzylamine	L L L L	No Yes No No	Yes Yes Yes Yes	27 <0.25 <0.25 2.4	1 5 (HCL) DMA DMA		3 2 3	3 - -	3 2 3	- - -	- X -	X X X	X - X	- X -	No No No Yes	Yes No No No	Reacts with water to form HCl No toxicity data found			
BZO BMA BEC BEF	Benzyl Dimethyl-octa-decylammonium Chloride Benzyl Trimethyl Ammonium Chloride Beryllium Chloride Beryllium Fluoride	S/L L S S	No No Yes No	Yes No No No	<0.25 <0.25 <0.25 <0.25	DMA DMA 0.002* (Be) 0.002* (Be)		U (3) (3) (3)	U (3) (3) (3)	U (3) (3) (3)	- - - -	- - - -	X X X X	X X X X	- - - -	Yes Yes Yes Yes	Yes Yes Yes Yes	Toxicity rating as beryllium Toxicity rating as beryllium			
BEH BED BEM BES	Beryllium Nitrate Beryllium Oxide Beryllium Metallic Beryllium Sulfate	S S S S	No No No No	No No Yes No	<0.25 <0.25 <0.25 <0.25	0.002* (Be) 0.002* (Be) 0.002* (Be) 0.002* (Be)	0.025	(3) (3) (3) (3)	- - - -	(3) (3) (3) (3)	- - - -	- - - -	X X X X	X X X X	- - - -	Yes Yes Yes Yes	Yes Yes Yes Yes	Toxicity rating as beryllium Toxicity rating as beryllium Toxicity rating as beryllium Toxicity rating as beryllium			
BGC BPA BDE BCP	Bismuth Oxide Bisphenol A Bisphenol A Diglycidyl Ether Boiler Compound-Liquid	S S L L	No No No No	No Yes Yes No	<0.25 <0.25 <0.25 -	DMA DMA 0.5 (2*)		(3) (3) (3) (2)	(3) (3) (3) (3)	1 (3) (3) (3)	X - - -	- - - -	- X X X	- X X X	X - - -	Yes Yes Yes Yes	Yes Yes Yes Yes	Toxic rating as phenol Toxic rating as phenol Toxic rating as NaOH			
BAC BTB SRT BRU	Boric Acid Boron Tribromide Boron Trichloride Bromine	S L L L	No Yes Yes No	No No No No	<0.25 114 >760 362	10* DMA DMA 0.1	3.0	(2) (3) (3) 3	(2) (3) (3) -	(2) (3) (3) 3	X - - -	- - - -	- X X X	- X X X	- - - -	Yes Yes Yes Yes	Yes Yes Yes Yes	Toxic rating as boron Toxic rating as boron Toxic rating as for HCL Toxic rating as for HCL			
BPR BTF BBZ BRU	Bromine Pentachloride Bromine Trifluoride Bromobenzene Brucine	L/G L L S	Yes Yes No No	No No Yes Yes	690 67 10 <0.25	0.1 (0.1) DMA DMA	0.3 (0.3)	(3) (3) 1 3	- (3) 2 -	(3) (3) 2 -	- - - -	- - X -	X X - X	X X - -	- - - -	No No No Yes	No No No No	Toxic rating as BFP			
BUI BUT BUD	Butadiene Inhibited Butane 1,3-Butanediol 1,4-Butenediol	G G L L	No No No No	Yes Yes Yes Yes	>760 >760 0.06 [20]	1000 500 DMA DMA	1250 750	2 U U U	- 0 U U	2 0 U U	- - - -	X X -	X X -	- - -	- - -	Yes Yes Yes Yes	Yes Yes Yes Yes				
BCN BTA BTA BAI	n-Butyl Acetate sec-Butyl Acetate tert-Butyl Acetate iso-Butyl Acrylate	L L L L	No No No No	Yes Yes Yes Yes	24 51 40 40	150 200 200 DMA	200 250 250	2 2 2 -	1 1 1 -	1 1 1 (2)	- - - -	X X X X	X X X X	- - - -	- - - -	Yes Yes Yes Yes	No Yes No (PVC) Yes	Toxicity as BIC			
BIC BAN BAS BAT	n-Butyl Acrylate n-Butyl Alcohol sec-Butyl Alcohol tert-Butyl Alcohol	L L L L	No No No No	Yes Yes Yes Yes	10.3 18 ~41 ~93	10 50 150 100	150	- 2 2 2	- 2 1 1	(2) 1 1 1	- - - -	X X X X	X X X X	- - - -	- - - -	Yes Yes Yes Yes	Yes Yes Yes Yes				
BUP BTM BPM BPN	tert-Butyl Hydroperoxide n-Butyl Mercaptan n-Butyl Methacrylate n-Butyl Amine	L L L L	No No No No	Yes Yes Yes Yes	~30 80 10 ~280	DMA 0.5 DMA 5/Salt		2 2 3 3	- - - -	2 2 2 2	- - - -	- - - -	X X X X	X - - -	- - - -	Yes No Yes Yes	Yes No Yes Yes	Highly reactive peroxide compound [5]			

C	CN	S	HR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAFETY HAZARD RATING			LEVELS OF PROTECTION				MATERIAL COMPATIBILITY (10)			NOTES	
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY			CLOTHING		B		P
												CC	AS	SS	MS				
BTL	sec-Butylamine	L	No	Yes	386	DNA	2	-	2	-	-	X	X	-	X	Yes	No	Asphyxiant	
BUA	tert-Butylamine	L	No	Yes	590	DNA	2	-	2	-	-	X	X	-	X	Yes	No		
BTM	Butylene	G	No	Yes	>760	DNA	-	-	-	-	-	-	X	-	-	Yes	Yes		
BTO	1,2-Butylene Oxide	L	No	Yes	370	DNA	3	-	3	-	-	-	X	-	-	Yes	Yes		
BTP	p-tert-Butylphenol	S	No	Yes	<0.1	DNA	-	-	2	-	-	X	-	-	X	Yes	Yes	Toxic rating as chlorosilanes, TLV as HCl	
BCS	Butyltrichlorosilane	L	Yes	Yes	41	(5)	(3)	-	(3)	-	-	-	-	-	-	Yes	No		
BTD	1,4-Butynediol	S	No	Yes	0.25	DNA	3	-	3	-	-	-	X	X	-	Yes	No	Toxic rating as aldehydes	
BAD	Iso-Butyraldehyde	L	No	Yes	248	DNA	(3)	(1)	(3)	-	-	-	X	X	-	Yes	No		
BTR	n-Butraldehyde	L	No	Yes	<248	DNA	(3)	(1)	(3)	-	-	-	X	-	-	Yes	No	Toxic rating as aldehydes	
BBA	n-Butyric Acid	L	No	Yes	<2.7	DNA	1	1	1	-	-	-	-	-	-	Yes	Yes		
CAA	Cacodylic Acid	S	No	No	<0.25	DNA	1	-	1	X	-	-	-	-	-	Yes	Yes	Toxic rating as cadmium compound Suspected carcinogen	
CAT	Cadmium Acetate	S	No	No	<0.25	0.05*(Cd)	(3)	-	(3)	-	-	-	X	-	-	Yes	Yes		
CHB	Cadmium Bromide	S	No	No	<0.25	0.05*(Cd)	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as cadmium compound Suspected carcinogen	
CDC	Cadmium Chloride	S	No	No	<0.25	0.05*(Cd)	(3)	-	(3)	-	-	-	X	-	-	Yes	Yes		
CFB	Cadmium Fluoborate	L	No	No	<0.25	0.0157	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as cadmium compound Suspected carcinogen	
CWN	Cadmium Nitrate	S	No	No	<0.25	0.05*(Cd)	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes		
COX	Cadmium Oxide	S	No	No	<0.25	0.05*(Cd)	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating as cadmium compound Suspected carcinogen	
CWS	Cadmium Sulfate	S	No	No	<0.25	0.05*(Cd)	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes		
CCA	Calcium Arsenate	S	No	No	<0.25	0.5*(As)	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Recognized carcinogen. Toxic rating as arsenic compound Toxic rating as arsenic compd.	
CAS	Calcium Arsenite	S	No	No	<0.25	DNA	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes		
CCB	Calcium Carbide	S	Yes	No	<0.25	5000	(1)	-	(1)	X	X	-	-	-	-	Yes	Yes	Toxic rating as calcium compd.	
CCC	Calcium Chlorate	S	No	No	<0.25	DNA	(1)	-	(1)	X	-	-	-	-	-	Yes	Yes		
CLC	Calcium Chloride	S	No	No	<0.25	DNA	(1)	-	(1)	X	-	-	-	-	-	Yes	Yes	Toxic rating as calcium compd.	
CCR	Calcium Chromate	S	No	No	<0.25	0.1*	(3)	-	(3)	-	-	-	X	-	-	Yes	Yes		
CCN	Calcium Cyanide	S	Yes	No	<0.25	S*	(3)	(3)	(1)	-	-	-	X	X	-	Yes	Yes	Toxic rating as CN Toxic rating as fluorides Toxic rating as calcium compd.	
CAF	Calcium Fluoride	S	No	No	<0.25	2.5*	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes		
CAH	Calcium Hydroxide	S	No	No	<0.25	DNA	(1)	-	(1)	X	-	-	-	-	-	Yes	Yes	Toxic rating as calcium compd.	
CHY	Calcium Hypochlorite	S	No	No	<0.25	DNA	3	-	2	-	-	-	-	-	-	Yes	Yes		
CAM	Calcium, Metallic	S	Yes	No	<0.25	DNA	(1)	-	(1)	X	X	-	-	-	-	Yes	Yes	Toxic rating as calcium compd. Toxic rating as nitrates Toxic rating as calcium compd.	
CNT	Calcium Nitrate	S	No	Yes	<0.25	DNA	(2)	-	(1)	X	-	-	-	-	-	Yes	Yes		
CAO	Calcium Oxide	S	Yes	No	<0.25	2*	(1)	-	(1)	X	-	-	-	-	-	Yes	Yes	Toxic rating as calcium compd.	
CCP	Calcium Peroxide	S	No	No	<0.25	DNA	(1)	-	(1)	X	-	-	-	-	-	Yes	Yes		
CAL	Calcium Phosphate	S	No	No	<<0.25	DNA	U	U	U	X	-	-	-	-	-	Yes	Yes	Not in TLV as Ph3 Toxic rating as Ph3 Pyrophoric Gives off flammable vapors when heated	
CPP	Calcium Phosphide	S	Yes	Yes	<<0.25	(0.3)/(0.4)*	(3)	-	(2)	-	-	-	-	-	-	Yes	Yes		
CRE	Calcium Resinate	S	No	Yes	<<0.25	DNA	U	U	U	-	-	-	-	-	-			Pyrophoric Gives off flammable vapors when heated	
CPI	Caephene	S	No	No	9.5	DNA	U	U	U	-	-	-	-	-	-				
CPD	Camphor (011)	L	No	Yes	0.7	3/30 min	-	-	2	-	-	X	-	-	-	Yes	Yes	Eye, skin irritant [9] Poisonous via skin	
CLS	Caprolactam (Solution)	L	No	Yes	0.12	5	-	-	-	-	-	-	-	-	-	Yes	Yes		
CPT	Capitan	S	No	No	<0.002	DNA	2	2	2	-	-	-	X	-	-	Yes	Yes		
CBY	Carbaryl	S	No	No	<0.25	5*	-	-	-	-	-	-	-	-	-	Yes	Yes		

C	CH	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAF-TOXIC HAZARD RATING				LEVELS OF PROTECTION					MATERIAL COMPAT- BILITY [10]			NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P			
CBO	Carbolic Oil	L	No	Yes	1.7	(5)		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as phenols		
CBO	Carbon Dioxide	G	No	No	>760	5000		1	-	-	-	X	X	-	-	Yes	Yes[12]			
CBR	Carbon Disulfide	L	No	Yes	570	20		3	3	3	-	-	X	X	-	No	(ACE)			
CBO	Carbon Monoxide	G	No	Yes	>760	50		3	-	-	-	-	X	X	-	Yes	Yes			
CBT	Carbon Tetrachloride	L	No	No	270	10	20	3	1	n	-	-	X	-	X	No[14]	(ACE)	By product wood turpentine		
CAR	Carene	L	-	Yes	5.1	DNA		3	3	3	-	-	X	X	-	Yes	Yes			
CTC	Catechol	S	No	Yes	<0.1	5/20*		3	-	3	-	-	X	X	-	Yes	Yes			
CPS	Caustic Potash (solution)	L	No	No	<0.25	2*		3	-	3	-	-	X	X	-	No	Yes[12]			
CSS	Caustic Soda (solution)	L	No	No	<0.25	DNA		2	-	3	-	-	X	X	-	Yes	No Yes[12]			
CHC	Charcoal	S	No	Yes	<<0.25	DNA		1	-	-	X	-	-	-	-	Yes	Yes			
CUN	Chlordane	L	No	Yes	<<0.25	0.027		3	3	-	-	-	X	X	-	Yes	Yes			
CLX	Chlorine	G	Yes	No	>760	1	3	3	-	x	-	-	X	X	-	Yes	Yes			
CTF	Chlorine Trifluoride	G/L	Yes	Yes	>760	0.1		(3)	-	(3)	-	-	X	X	-	No		Toxic rating as chlorine, fluorine, fluorides	Highly toxic Powerful lachrymator TLV & toxic rating as HCl	
CTD	4-Chloro-o-Toluidine	S	-	Yes	<0.9	DNA		3	-	3	-	-	X	X	-	No				
CRA	Chloroacetylene	S	No	Yes	0.25	0.345*		(3)	-	(3)	-	-	X	X	-	Yes	No			
CAC	Chloroacetyl Chloride	L	Yes	No	30	(5)		(3)	-	(3)	-	-	X	X	-	Yes	No			
CAP	p-Chloroaniline	S	No	Yes	0.26	(2)	(5)	(3)	(3)	-	-	-	X	X	-	Yes	Yes	Toxic rating & TLV as aniline	Organic cyanide Suspected carcinogen	
CRB	Chlorobenzene	L	No	Yes	26	75		2	1	1	-	-	X	X	-	No	No			
CBM	4-Chlorobutyronitrile	L	No	-	1.7	DNA		3	-	1	-	-	X	X	-	No	No			
CRF	Chloroform	L	No	Yes	346	25		3	-	1	-	-	X	X	-	No	No			
CHD	Chlorohydrin (crude)	L	No	Yes	16	5		U	U	U	-	-	-	X	X	-	No	Irritant Toxic rating as chloroethyl ether Highly toxic Toxic rating as phenol		
CME	Chloromethyl Methyl Ether	L	Yes	Yes	180	1 [2]		(3)	(3)	(3)	-	-	X	X	-	-	-			
CNC	o-Chloronitrobenzene	L	No	Yes	0.66	DNA		3	U	U	-	-	X	X	-	Yes	Yes			
CNP	p-Chlorophenol	S	No	Yes				(3)	(3)	(3)	-	-	X	X	-	-	-			
CPL	Chloropicrin	L	No	Yes	44	0.1	0.3	3	-	3	-	-	X	X	-	Yes	Yes	Lachrymator & irritant		
CRP	Chloroprene	L	No	Yes	26	25	35	2	3	2	-	-	X	X	-	No	No			
CSA	Chlorosulfonic Acid	L	Yes	Yes	1.6	(5.0)[9]		(3)	-	(3)	-	-	X	X	-	No(PVC)	(No)(PVC)			
CKW	p-Chlorotoluene	L	No	Yes	7.6	DNA		U	U	U	-	-	-	-	-	No[11]	[10]			
CRT	Chromic Acetate	S	No			(0.05)*		(3)	-	(3)	-	-	X	X	-	-	-	As chromic compound, recognized carcinogen		
CMA	Chromic Anhydride	S	No	No	<0.25	(0.05)*		(3)	-	(3)	-	-	X	X	-	Yes	Yes			
CHS	Chromic Sulfate	S	No	-		(0.05)*		(3)	-	(3)	-	-	X	X	-	Yes	No			
CRC	Chromous Chloride	S	No	-		(0.05)*		(3)	-	(3)	-	-	X	X	-	-	-			
CNC	Chromyl Chloride	L	Yes	No	32	(0.05)*		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Non-toxic[5], moderately irritant organic acid[8]	As cobalt compounds	
CIT	Citric Acid	S	No	Yes	<0.25	DNA		(1)	-	-	-	-	-	-	-	Yes	Yes			
CBA	Cobalt Acetate(ous)	S	No	No	<0.25	0.1*(Co)		(2)	-	-	-	-	-	-	-	Yes	Yes			
COR	Cobalt Bromide(ous)	S	No	No		DNA		(2)	-	-	-	-	-	-	-	Yes	Yes			
CBC	Cobalt Chloride(ous)	S	No	No	<0.25	0.1*(Co)		(1)	-	-	-	-	-	-	-	Yes	Yes	As cobalt compounds	As fluorides	
COF	Cobalt Fluoride(ous)	S	Yes		(2.5)*[5]	(F)		(3)	-	(3)	-	-	X	X	-	-	-			
CFM	Cobalt Formate(ous)	S	No	Yes	<0.25	DNA		(2)	-	(2)	-	-	-	-	-	-	-			
CON	Cobalt Nitrate(ous)	S	No	Yes	<0.25	0.1*(Co)		(2)	-	(2)	-	-	-	-	-	Yes	Yes			

C	CM	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAF-TOXIC HAZARD RATING				LEVELS OF PROTECTION					MATERIAL COMPAT- BILITY [10]			NOTES
												RESPIRATORY			CLOTHING					
						THA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P			
COS	Cobalt Sulfamate(ous)	S	No	No	<0.25	DNA		U	U	U	X	-	-	-	X	Yes	Yes	Primarily a respiratory threat		
CBS	Cobalt Sulfate(ous)	L	No	Yes	DNA	400 [9]		(2)	(2)	(2)	-	X	X	-	X	Yes	No	Toxicity based on ether content		
CLD	Collodion	S	No	No	<0.25	(1)*		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As copper compds; TMA as 0.2% as times		
COP	Copper Acetic(ic)	S	No	No	<0.25	(1)*		(3)	(3)	(2)	-	-	-	-	-	Yes	Yes	As arsenic compounds, recog- nized carcinogen " "		
CAA	Copper Acetoarsenite(ic)	S	No	No	<0.25	0.5*(As)		(3)	(3)	(2)	-	-	-	-	-	Yes	Yes	" "		
CPA	Copper Arsenite(ic)	S	No	No	<0.25	[9]		(3)	(3)	(2)	-	-	-	-	-	Yes	Yes	As bromides & copper compounds		
CPB	Copper Bromide(ic)	S	No	No	<0.25	DNA		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As bromides & copper compounds		
CB0	Copper Bromide(ous)	S	No	No	<0.25	DNA		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As bromides & copper compounds		
CPC	Copper Chloride(ic)	S	No	No	<0.25	DNA		(2)	(3)	(1)	-	X	X	-	X	Yes	Yes	As copper compounds		
CCY	Copper Cyanide(ous)	S	No	No	<0.25	5* [9]		(2)	(3)	(3)	-	-	X	X	-	Yes	Yes	As cyanides		
CPF	Copper Fluoroborate(ic)	L	No	No	<0.25	DNA		(2)	(3)	(1)	-	-	X	X	-	Yes	Yes	As fluoride & fluoroborate		
CUF	Copper Formate(ic)	S	No	No	<0.25	DNA		(2)	(2)	(1)	-	-	-	-	-	Yes	Yes	As copper compounds		
CPG	Copper Glycinate	S	No	-	-	(1)*Cu					X	-	-	-	X	Yes	Yes	TLV as copper compd, additive to animal feed		
CLD	Copper Iodide(ous)	S	No	No	<0.25	(1)*Cu		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As copper compd, toxic rating & TLV		
CLT	Copper Lactate(ic)	S	No	-	7.4	(1)*Cu		(2)	(2)	(1)	-	-	-	-	-	Yes	Yes	" "		
CNN	Copper Naphthenate(ic)	L	-	Yes	7.4	500[9]		(2)	(2)	(1)	-	-	-	-	-	Yes	Yes	" "		
CNI	Copper Nitrate(ic)	S	No	Yes	<0.25	(1)*Cu		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As copper compd, toxic rating		
COL	Copper Oxalate(ic)	S	No	No	<0.25	(1)*Cu		(2)	(2)	(3)	-	-	-	-	-	Yes	Yes	As copper & oxalate compounds		
CST	Copper Subacetate(ic)	S	No	-	<0.25	(1)*Cu		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As copper compounds		
CSF	Copper Sulfate(ic)	S	No	No	<0.25	(1)*Cu		(2)	(2)	(1)	-	X	X	-	X	Yes	Yes	As copper compounds		
CSN	Copper Sulfate(ic) Ammoniated	S	No	-	-	(1)*Cu		(3)	(3)	(1)	-	-	-	-	-	Yes	Yes	As ammonia; TLV as copper		
CTT	Copper Tartrate(ic)	S	No	-	-	(1)*Cu		(2)	(2)	(1)	-	-	-	-	-	Yes	Yes	As copper compounds, toxic rating & TLV		
CSY	Corn Syrup	L	No	No	-	DNA					-	-	-	-	-	Yes	Yes	Nonotoxic [6]		
COU	Coumaphos	S	No	-	<0.25	DNA					-	-	-	-	-	Yes	Yes	Cholinesterase inhibitor [5]		
CCT	Cresote, Coal Tar	L	No	Yes	<0.1	DNA		2	-	2	-	-	X	X	-	Yes	Yes	Recognized carcinogen of skin; experimental carcinogen of lungs		
CRS	Cresols	L	No	Yes	1.7	5		2	2	2	-	X	X	-	X	Yes	Yes			
CGE	Cresyl Glycidyl Ether	S	-	Yes	<1.0	DNA					-	-	-	-	-	Yes	Yes			
CTA	Crotonaldehyde	L	No	Yes	7.7	2		3	3	3	-	-	X	X	-	Yes	No			
CUM	Cumene	L	No	Yes	25	50		3	3	3	-	-	X	X	-	Yes	Yes			
CMH	Cumene Hydroperoxide	L	No	Yes	0.8	DNA		3	3	3	-	-	X	X	-	Yes	Yes	Strong irritant to tissues.		
CES	Cupriethylenediamine Solution	L	-	-	DNA	DNA		-	-	-	-	-	-	-	-	Yes	Yes	toxic [5]		
CYA	Cyanoacetic Acid	S	No	Yes	~ 0.2	(5)*[8]		(3)	(3)	(1)	-	-	X	X	-	Yes	Yes	As cyanides, toxic rating & TLV		
CYG	Cyanogen	G	No	Yes	>760	10		(3)	(3)	(1)	-	-	X	X	-	Yes	Yes	As cyanides		
CBR	Cyanogen Bromide	S	Yes	No	280	0.5 [9]		(3)	(3)	(1)	-	-	X	X	-	Yes	Yes	As cyanides		
CCL	Cyanogen Chloride	L/G	No	No	>760	0.5 [9]		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	As hydrochloric acid		
CHX	Cyclohexane	L	No	Yes	165	300		2	-	2	-	-	-	-	-	No	Yes[12]			
CHM	Cyclohexanol	S/L	No	Yes	3.1	50		2	1	1	-	-	X	X	-	Yes	Yes	Suspected carcinogen		
CCN	Cyclohexanone	L	No	Yes	~39	50		1	-	2	-	-	-	-	-	Yes	No	Peroxide, organic-irritating to skin, eyes		
CHP	Cyclohexanone Peroxide	L	No	Yes	39	DNA					-	-	X	X	-	Yes	Yes	As hydrochloric acid, TLV & toxic rating		
CHT	Cyclohexenyltrichlorosilane	L	Yes	Yes	DNA	(5)		(3)	-	(3)	-	-	-	-	-	Yes	No			

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> ) <sup>a</sup>		SAFETY RATING				LEVELS OF PROTECTION				MATERIAL COMPAT- IBILITY [10]			NOTES
						TLV	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P		
CHA	Cyclohexylamine	L	No	Yes	22	10		3	3	2	-	-	X	X	-	Yes	No		
CYP	Cyclopentane	L	No	Yes	520	DNA		2	-	-	-	X	X	-	X	Yes	Yes		
CPR	Cyclopropane	G	No	Yes	720	400 [9]		2	-	-	-	X	X	-	X	Yes	Yes		
CP	p-Cymene	L	No	Yes	3.5	DNA		(2)	-	-	-	X	X	-	X	Yes	Yes		As toluene, toxic rating
DES	2,4-D Esters	L	No	-	<0.25	DNA													Moderately toxic, irritant as acid [5], herbicide
DLP	Dalapon	L	No	-	<0.25	DNA		2	-	-	-	X	-	-	X	Yes	Yes		Skin adsorption from solutions, insoluble in water
DDO	DDO	S	No	No	<0.25	DNA		1	-	-	-	-	-	-	-	Yes	Yes		Toxic by inhalation & ingestion
DDT	DDT	S	No	Yes	<0.25	1		(3)	-	(3)	-	-	X	X	-	Yes	Yes		Toxic rating as boron hydride high toxicity, skin absorp.
DBR	Decaborane	S	Yes	Yes	0.18	0.3*		(3)	-	(3)	-	-	X	X	-	Yes	Yes		Aldehyde
DM	Decaldehyde	L	No	Yes	0.27	25		(3)	(1)	(3)	-	-	X	X	-	Yes	No		Irritant & narcotic. Toxicity rating as hexene.
DAL	1-Decene	L	No	Yes	1.7	DNA		(2)	-	(2)	-	-	X	X	-	Yes	Yes		Animal experiments indicate low toxicity.
DCE	1-Decene	L	No	Yes	2.7	DNA		(2)	-	(2)	-	-	X	X	-	Yes	Yes		Toxic rating as parathion. Cholinesterase inhibitor.
DAN	Decyl Alcohol	L	No	Yes	0.02	DNA		U	U	U	-	-	-	-	-	Yes	Yes		Non-toxic [5]
DBZ	n-Decylbenzene	L	No	Yes	<0.02	DNA		U	U	U	-	-	-	-	-	Yes	Yes		High toxicity [8]
DTN	Demeton	L	No	Yes	<0.25	0.0087		(3)	-	-	-	-	-	-	-	Yes	Yes		Irritating to eyes, skin, membrane.
DTS	Dextrose Solution	L	No	No	<0.25	DNA		U	U	U	-	-	-	-	-	Yes	Yes		Organic peroxide [8]
DZP	Di-(2-Ethylhexyl) Phosphoric Acid	L	No	Yes	0.25	DNA					-	-	-	-	-	Yes	Yes		Toxic rating as amyl alcohol
DZP	Di-(p-Chlorobenzoyl) Peroxide	L	No	Yes	0.25	DNA		(3)	-	(1)	-	-	X	X	-	No	No		Toxic rating as phthalic acid
DAP	Di-n-Amyl Phthalate	L	No	Yes	0.25	DNA		(3)	-	(2)	-	-	X	X	-	No	No		Classed as ketone
DRE	Di-n-Butyl Ether	L	No	Yes	13.5	DNA		(2)	-	(1)	-	-	X	X	-	No	No		High vapor pressure, irritating organic amine
DBK	Di-n-Butyl Ketone	L	No	Yes	-	DNA		3	-	3	-	-	X	X	-	Yes	No		
DGA	Di-n-Butylamine	L	No	Yes	5.8	DNA		U	U	U	-	-	X	X	-	Yes	Yes		
DNA	Di-n-Propylamine	L	No	Yes	>50	DNA		2	-	2	-	-	X	X	-	Yes	Yes		
DAA	Diacetone Alcohol	L	No	Yes	3.3	50		2	-	2	-	-	X	X	-	Yes	Yes		
DZN	Diazinon	L	No	Yes	<0.25	0.1*		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes		
DPO	Dibenzoyl Peroxide	S	No	Yes	<0.003	0.403		2	(2)	(2)	-	-	X	X	-	Yes	Yes		
DPA	Dibutyl Phthalate	L	No	Yes	<0.01	(5)		(2)	(2)	(2)	-	-	X	X	-	Yes	Yes		
DPT	Dibutyl Phenol	S	No	Yes	<0.25	(10)		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes		
DCA	Dicamba	S	No	-	DNA	DNA					-	-	-	-	-				
DIB	Dichlobenil	S	No	-	<0.001	DNA					-	-	-	-	-				
DCL	Dichlorone	S	No	-	<0.001	DNA					-	-	-	-	-				
DTM	4,4-Dichloro-Alpha Trichloromethyl-Benzhydrol	S	No	Yes	<0.25	DNA		2	-	2	-	-	X	X	-	Yes	Yes		
DBO	o-Dichlorobenzene	L	No	Yes	3.2	50		2	-	3	-	-	X	X	-	No	Yes		
DBP	p-Dichlorobenzene	S	No	Yes	4.8	75		1	-	1	-	-	X	X	-	Yes	Yes		
DCB	Dichlorobutene	L	No	Yes	7.4	DNA		U	U	U	-	-	X	X	-	Yes	Yes		
DCF	Dichlorodifluoromethane	G	No	No	>760	1000		1	-	-	-	-	-	-	-	Yes	Yes		
DCH	1,1-Dichloroethane	L	No	Yes		DNA		2	-	1	-	-	X	X	-	No [14]	No		
DEE	Dichloroethyl ether	L	Yes	Yes	1.2	5		3	3	3	-	-	X	X	-	No	No		
DEL	1,2-Dichloroethylene	L	No	Yes	432	200		2	2	2	-	-	X	X	-	Yes	Yes		
DCH	Dichloromethane	L	No	Yes	>760	200		3	2	2	-	-	X	X	-	Yes	No		

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAFETY HAZARD RATING				LEVELS OF PROTECTION					MATERIAL COMPATIBILITY [10]		NOTES
												RESPIRATORY			CLOTHING				
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	MS	B	P		
DCP	2,4-Dichlorophenol	S	No	Yes	0.35	DNA		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as chlorinated phenols	
DCA	2,4-Dichlorophenoxyacetic Acid	S	No	Yes	<0.25	10*		2	-	2	X	X	-	-	X	Yes	Yes		
DPP	1,2-Dichloropropane	L	No	Yes	93	75		3	3	2	-	-	X	X	-	Yes	No		
DPR	Dichloropropene	L	No	Yes	026	DNA		2	-	2	-	-	X	-	X	Yes	No		
DCV	Dichlorovos	L	No	-	14*	0.1					-	-	X	X	-	Yes	Yes	Highly toxic [8]	
DPT	Dicyclopentadiene	S	No	Yes	6.5	75		3	3	-	-	-	X	X	-	Yes	Yes	Very toxic [8]	
DEC	Diethylenediamine	L	No	Yes	<0.01	DNA		1	-	-	-	-	X	-	-	Yes	No	Low toxicity	
DEA	Diethanolamine	L	No	Yes															
DEC	Diethyl Carbonate	L	No	Yes	21	200		2	-	2	-	X	X	-	X	Yes	Yes		
DPH	Diethyl Phthalate	L	No	Yes	<0.25	5*		2	-	2	-	X	X	-	X	Yes	No		
DEN	Diethylamine	L	No	Yes	39	25		2	-	2	-	X	X	-	X	Yes	No		
DEB	Diethylbenzene	L	No	Yes	2.6	DNA		2	-	2	-	X	X	-	X	Yes	No		
DEG	Diethylene Glycol	L	No	Yes	0.01	100		2	-	1	-	X	X	-	X	Yes	Yes	As glycol	
DGD	Diethylene Glycol Dimethyl Ether	L	No	Yes	6.0	DNA		(2)	-	(1)	-	X	X	-	X	Yes	No	As glycol	
DNE	Diethylene Glycol Monobutyl Ether	L	No	Yes	0.17	DNA		(2)	-	(1)	-	X	X	-	X	Yes	No	As glycol	
DEM	Diethylene Glycol Monobutyl Ether Acetate	L	No	Yes	0.02	DNA		(2)	-	(1)	-	X	X	-	X	Yes	No		
DGE	Diethylene Glycol Monoethyl Ether	L	No	Yes	0.6	100		(2)	-	(1)	-	X	X	-	X	Yes	No	As glycol	
DGM	Diethylene Glycol Monomethyl Ether	L	No	Yes	0.7	DNA		(2)	-	(1)	-	X	X	-	X	Yes	No	As glycol	
DET	Diethylenetriamine	L	No	Yes	1.1	1		2	-	2	-	X	X	-	X	Yes	No	Decomposes violently in water, ignites spontaneously in air	
DEZ	Diethyl Zinc	L	Yes	Yes	36.1	DNA													
DFF	1,1-Difluoroethane	G	No	Yes	>760	200		2	-	1	-	X	X	-	X	Yes	Yes	Toxic rating as fluorides	
DFA	Difluorophosphoric Acid Anhydrous	L	Yes	No	58	DNA		(3)	-	(3)	-	-	-	-	-	Yes	No	Toxic rating as DID	
DHP	Dienophthalate	L	-	Yes	<0.25	DNA		2	-	2	-	-	-	-	-	Yes	No		
DIK	Diisobutyl Ketone	L	No	Yes	5.0	25		-	-	-	-	-	-	-	-	Yes	No		
DBC	Diisobutylcarbinol	L	No	Yes	3	DNA					-	X	X	-	X	Yes	Yes	Animal experiments indicate low toxicity	
DEL	Diisobutylene	L	No	Yes	67	DNA		1	-	2	-	X	-	-	X	Yes	Yes	Narcotic in high concentration	
DID	Diisododecylphthalate	L	-	Yes	<0.25	DNA		-	-	-	-	-	-	-	-	No	Yes	Low toxicity [5]	
DIP	Diisopropylamine	S/L	No	Yes	<0.02	DNA										Yes	No		
DIA	Diisopropylamine	L	No	Yes	136	5.0		2	2	2	-	X	X	-	X	Yes	No	Strong oxidizer,probably toxic	
DIH	Diisopropylbenzene	L	-	-	<0.25	DNA		U	U	U	-	-	X	-	-	No	Yes		
DIM	Dimethyl Ether	G	No	Yes	>760	DNA		2	2	2	-	-	X	X	-	Yes	Yes		
DSF	Dimethyl Sulfate	L	No	Yes	1.6	0.1		3	3	3	-	-	X	-	-	Yes	Yes		
DSL	Dimethyl Sulfide	L	No	Yes	>760	DNA		U	U	U	-	-	X	-	-	Yes	Yes	Probably highly toxic, see sulfides as irritant	
DMS	Dimethyl Sulfoxide	L	No	Yes	1.5	DNA		1	2	2	-	X	-	-	X	Yes	Yes	Dust not harmful	
DNT	Dimethyl Terephthalate	S	No	Yes	<0.01	DNA		3	3	3	-	-	-	-	-	Yes	No		
DAC	Dimethylacetamide	L	No	Yes	4.2	10										Yes	No		
DMA	Dimethylamine	G	No	Yes	>760	10		2	-	2	-	X	X	-	X	Yes	No	Toxic rating as chlorosilanes	
DMD	Dimethyldichlorosilane	L	Yes	Yes	240	DNA		(3)	-	(3)	-	-	-	-	-	Yes	No	Organic peroxides, irritant to skin & tissue & eyes	
DHF	Dimethylformamide	L	No	Yes	0.8	10		2	-	2	-	-	X	-	-	Yes	No		
DDM	Dimethylhexane Dihydroperoxide, Met	S	No	Yes	<0.25	DNA													

C	CM	S	MR	F	VP	TLV (PPM OR MG/M3)*		SAFETY HAZARD RATING				LEVELS OF PROTECTION				MATERIAL COMPAT- IBILITY [10]			NOTES
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY			CLOTHING		B	P	
												CC	AS	SS	NS	SS			
DH	1,1 Dimethylhydrazine	L	Yes	Yes	<5	0.5	1.0	3	3	3	-	-	-	X	X	-	Yes	No	Experimental carcinogen 10 ppm in food (0 in milk)[5] Irritating to eyes Pyrophoric
DHP	Dimethylolylsiloxane	L	No	Yes	DNA	DNA					-	-	-	-	-	-			
DHZ	Dimethylzinc	L	-	-	595	DNA		2	-	2	X	-	-	-	Fire	Suit			
DIT	2,4-Dinitroaniline	S	No	Yes	<0.25	DNA													Slight fire hazard As dinitrobenzene, toxic rating As 2-3 dinitrophenol
DNZ	Dinitrobenzene	S	No	Yes	<0.1	0.15/1*	0.5	3	3	-	-	-	-	X	X	-	Yes	Yes	
DNB	Dinitrobenzene (M-)	S	No	Yes	<0.25	0.1* [9]		3	3	3	-	-	-	X	X	-	Yes	Yes	
DNC	Dinitroresols	S	No	Yes	<0.01	0.2* [9]		3	3	(3)	-	-	-	X	X	-	Yes	Yes	
DNP	2,4-Dinitrophenol	S	No	Yes	<0.25	DNA		(3)	(3)	(3)	-	-	-	X	X	-	Yes	Yes	
DOT	2,4-Dinitrotoluene	S	No	Yes	<0.01	1.5* [9]		3	3	1	-	-	-	X	X	-	Yes	Yes	Low toxicity[5], irritating to eyes Low vapor pressure
DOA	Dioctyl Adipate	L	No	Yes	<0.25	DNA					-	-	-	-	-	-	Yes	No	
DOP	Diocetyl Phthalate	L	No	Yes	<0.25	DNA		2	-	0	-	-	X	-	-	-	Yes	No	
DOS	Diocetyl Sodium Sulfosuccinate	S/L	No	No	<0.25	DNA		1	-	1	-	-	-	-	-	-	Yes	Yes	
DOZ	1,4-Dioxane	L	Yes	Yes	67	50		3	2	2	-	-	-	X	-	-	No	Yes	Vapor toxic by inhalation[8]; Low toxicity [5]
DPM	Dipentene	L	No	Yes	5.7	DNA		1	-	2	-	-	-	-	-	-	Yes	No	
DPE	Diphenylether	L	No	Yes	0.2	1.0 [9]					-	-	-	-	-	-	Yes	Yes	
DAM	Diphenylamine	S	No	Yes	<0.25	10* [9]		3	3	-	-	-	-	X	X	-	Yes	Yes	
DPO	Diphenyldichlorosilane	L	Yes	Yes [5]	<0.01	DNA		3	-	3	-	-	-	X	X	-	Yes	Yes	Toxic, strong irritant [5] Moderately toxic by ingestion[5] Highly toxic contact herbicide & desiccant; see paraquat
DPM	Diphenylmethane Diisocyanate	S	Slow	Yes	<0.01	0.02 [5]		U	U	U	-	-	-	X	X	-	Yes	Yes	
DPE	Dipropylene Glycol	L	No	Yes	<0.01	DNA		3	3	3	-	-	-	-	-	-	Yes	Yes	
DLC	Diquat	S	No	-	0.5*						-	-	-	-	-	-			Mixed hydrocarbon-low toxicity
DF	Distillates, Flashed Feed Stocks	L	No	Yes	93	500/30 min [9]					-	-	-	X	-	-	No	No	Same as DFF
DSR	Distillates, Straight Run	L	No	Yes	93	0.1*					-	-	-	X	-	-	No	No	Insecticide, cholinesterase in- hibitor [5]
DIS	Disulfon	L	No	-	DNA						-	-	-	-	-	-			Phthalate, hydrolytic to di- phenylamine [5]
DIU	Diuron	S	No	-	-	10*		U	U	U	-	-	-	X	X	-			Low toxicity[5]; animal experi- ments indicate low toxicity[8] Probably irritant & narcotic in high conc. [5]
DDM	Dodecanoic	S	No	Yes	0.03	DNA		U	U	U	X	-	-	-	-	-	Yes	Yes	Same as above [5] Biodegradable; strong org. acid
DDO	Dodecene	L	No	Yes	0.56	200 [9]		U	U	U	-	-	-	-	-	-	Yes	Yes	As DSA, some skin irritation
DDC	1-Dodecene	L	No	Yes	0.56	DNA					-	-	-	-	-	-			Irritates eyes & skin
DAS	Dodecyl Benzene Sulfonic Acid	S	No	Yes	-	DNA					X	-	-	-	-	-	Yes	Yes	Irritates eyes & skin
DSD	Dodecyl Benzene Sulfonic Acid, Sodium Salt	S	No	Yes	<0.25	DNA					-	-	-	-	-	-			
DSO	Dodecyl Sulfate, Diethanolamine Salt	L	-	-	<0.25	DNA					-	-	-	-	-	-			
DSM	Dodecyl Sulfate, Magnesium Salt	L	-	-	<0.25	DNA					-	-	-	-	-	-			
DOS	Dodecyl Sulfate, Sodium Salt	S	-	-	<0.25	DNA					-	-	-	-	-	-			
DST	Dodecyl Sulfate, Triethanolamine Salt	L	-	Yes [5]	<0.25	DNA		U	U	U	-	-	-	X	X	-			Irritates eyes & skin Moderately toxic by ingestion [5], see benzene [5]
DDB	Dodecylbenzene	L	No	-	<0.25	DNA					-	-	-	-	-	-			Similar to DSA
DCS	Dodecylbenzene Sulfonic Acid, Calcium Salt	L	-	Yes	<0.25	DNA					-	-	-	-	-	-			
DAL	Dodecylbenzene Sulfonic Acid, Isopropylamine Salt	S	-	-	<0.25	DNA					-	-	-	-	-	-			
DTS	Dodecylbenzene Sulfonic Acid, Triethanolamine Salt	L	-	-	<0.25	DNA		(3)	-	(3)	-	-	-	-	-	-	Yes	No	Based on triethanolamine
DTC	Dodecyltrichlorosilane	L	Yes	Yes	<0.03	DNA					-	-	-	X	X	-	Yes	Yes	As silanes; irritant, toxic aq.
DTH	Dodecyltrichlorosilane	L	No	Yes	<0.07	DNA		(3)	-	(3)	-	-	-	-	-	-	Yes	Yes	Liquid heating transfer media
DUR	Dursban	L	-	-	<0.07	DNA					-	-	-	X	X	-			As parathion; cholinesterase inhibitor

C	CN	S	MR	F	VP	TLV (ppm or mg/m <sup>3</sup> ) <sup>a</sup>		SAF-TOXIC HAZARD RATING			LEVELS OF PROTECTION					MATERIAL COMPATIBILITY (10)			NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P		
ESF	Endosulfane	S	No	-		0.1*[5]							X	X	-				Highly toxic insecticide; skin adsorption
EDM	Enderlin	S	No	Yes	<0.01	0.1*[9]		(3)	(3)				X	X	-	Yes	Yes	Yes	As aldrins; insecticide
EPC	Epichlorohydrin	L	No	Yes	34	5	10	3	3				X	X	-	Yes	Yes	Yes	Not harmful
EVO	Epoxid Vegetable Oils	L	-	Yes		DNA													
ETM	Ethane	G	No	Yes	>760	1000		2	(3)				X	X	-	Yes	Yes	Yes	As parathions; cholinesterase inhibitor
ETO	Ethion	L	No	-		0.4 <sup>a</sup>		(3)					X		-	Yes	Yes	Yes	Low toxicity [5]; most glycols not toxic [8]
ETG	Ethoxy Triglycol	L	No	Yes	<0.1	DNA									X				Mod. toxic in animal experiments
ENP	Ethoxyhydrourean	L	No	Yes [5]	DNA			U	U							Yes	Yes	Yes	Burns eyes, irritates skin, surfactant
EOD	Ethoxylated Dodecano	L	No	Yes	<0.25	DNA		U	U							Yes	Yes	Yes	Irritates skin & eyes, surfactant
END	Ethoxylated Nonylphenol	L	-	-	<0.25	DNA		U	U							Yes	Yes	Yes	Burns eyes, irritates skin
EOP	Ethoxylated Pentadecano	L	No	Yes	<0.25	DNA		U	U							Yes	Yes	Yes	Burns eyes, irritates skin
EOT	Ethoxylated Tetradecano	L	No	Yes	<0.25	DNA		U	U							Yes	Yes	Yes	Burns eyes, irritates skin
ETD	Ethoxylated Tridecano	L	No	Yes	<0.25	DNA		2	2							Yes	Yes	Yes	Burns eyes, irritates skin
ETA	Ethyl Acetate	L	No	Yes	165	400		2	-				X	X	-	Yes	Yes	Yes	
EAA	Ethyl Acetoacetate	L	No	Yes	5	50[2]		2	-				X	X	-	Yes	Yes	Yes	
EAC	Ethyl Acrylate	L	No	Yes	77	25		3	3				X	X	-	Yes	Yes	Yes	
EAL	Ethyl Alcohol	L	No	Yes	67	1000		2	1				X	X	-	Yes	Yes	Yes	Low toxicity [5]; no general state
EBT	Ethyl Butanol	L	No	Yes	3.5	2		-	-				X	-		Yes	Yes	Yes	ment; alcohols, burns eyes
EBM	Ethyl Butyrate	L	No	Yes	37	DNA		U	U							Yes	No	No	Irritating to eyes & mucous membranes; narcotic in high conc. [5]
ECI	Ethyl Chloride	G	Yes	Yes	>760	1000		2	-				X	-		Yes	No (ACE)	No	
ECA	Ethyl Chloroacetate	L	Yes	Yes	10	DNA		2	-				X	X	-	Yes	No	No	
ECF	Ethyl Chloroformate	L	Yes	Yes	19	DNA		3	-				X	X	-	Yes	No	No	
EET	Ethyl Ether	L	No	Yes	>760	400		2	2				X	X	-	Yes	No (ACE)	No	
EEM	Ethyl Formate	L	Yes	Yes	413	100		2	-				X	X	-	Yes	No	No	
ENI	2-Ethyl Hexanol	L	No	Yes	0.7	DNA		-	-							Yes	Yes	Yes	Low toxicity [5]
ELT	Ethyl Lactate	L	No	Yes	10	DNA		-	-				X	X	-	Yes	No	No	Low toxicity [5]; harmful if swallowed
ENC	Ethyl Mercaptan	L	Yes	Yes	>760	0.5	2.0	2	-				X	X	-	Yes	Yes	Yes	Moderately toxic [5]
ENM	Ethyl Methacrylate	L	No	Yes	37	DNA		-	-							Yes	Yes	Yes	Readily polymerizes; mod. toxic & irritating in animal exp. [5]
ETB	Ethyl Nitrite	L/G	Yes	Yes	>760	DNA		2	-							Yes	Yes	Yes	Narcotic high conc. [8]
EPD	Ethyl Phosphonothioic Dichloride, Anhydrous	L	-	Yes	5.1	DNA		U	U					X	-				Corrosive, highly toxic [8], poisonous gas contact w/water
EPP	Ethyl Phosphorodichloride	L	Yes	Yes	3.8	DNA		2	-				X	X	-	Yes		Yes	Burns skin & eyes
ESC	Ethyl Silicate	L	Yes	Yes	5.5	100		-	-				X	X	-	Yes		Yes	
EPA	2-Ethyl-3-Propylacrolein	L	No	Yes	3.6	DNA		2	-				X	X	-	Yes	Yes	Yes	Powerful odor [5]
EBD	Ethyl Aluminum Dichloride	L	Yes	Yes	1.5	DNA		-	-							Yes	No	No	Very irritating & toxic, pyrophoric, pyrophoric suit
EAS	Ethyl Aluminum Sesquichloride	L	Yes	Yes	1.5	DNA		-	-							Yes	No	No	Pyrophoric, fire suit
EMM	Ethylamine	L	No	Yes	>760	10		3	-				X	X	-	Yes			
ETB	Ethylbenzene	L	No	Yes	19	100	125	2	2				X	X	-	No	No	No	
EDS	Ethylchlorosilane	L	Yes	Yes	213	DNA		3	-				X	X	-	Yes	Yes	Yes	
ETL	Ethylene	G	No	Yes	>760	1000		2	0				X	X	-	Yes	Yes	Yes	
EDM	Ethylene Chlorohydrin	L	Yes	Yes	14.6	5		3	3							Yes	No	No	

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAX-TOXIC HAZARD RATING		LEVELS OF PROTECTION					MATERIAL COMPAT- BILITY			NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P	
ETC	Ethylene Cyanohydrin	L	Yes	Yes	0.15	DNA		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as CN
EDB	Ethylene Dibromide	L	No	No	28	0.385		3	3	3	-	-	X	X	-	Yes	Yes	
EDC	Ethylene Dichloride	L	No	Yes	139	5		3	-	3	-	-	X	X	-	Yes	No	Ingestion hazard, toxic in particulate form [8]
EGL	Ethylene Glycol	L	No	Yes	0.25	100					-	-	-	-	X	Yes	Yes	
EGY	Ethylene Glycol Diacetate	L	No	Yes	1.0	DNA		U	U	U	-	X	-	-	X			Low toxicity[5], irritates skin & eyes
EEE	Ethylene Glycol Diethyl Ether	L	No	Yes	9.7	DNA					-	-	X	-	X			
EGD	Ethylene Glycol Dimethyl Ether	L	No	Yes	119	DNA		U	U	U	-	-	X	-	X	Yes	No	Fire risk[5], not skin irritant
EGA	Ethylene Glycol Monobutyl Ether	L	No	Yes	1.9	50		-	-	-	-	-	X	-	X	Yes	No	Toxicity-glycol mod. toxic[5]
ENA	Ethylene Glycol Monobutyl Ether Acetate	L	No	Yes	0.37	DNA		-	-	-	-	X	-	-	X	Yes[11]		Low toxicity[5], irritates skin & eyes
EGE	Ethylene Glycol Monoethyl Ether	L	No	Yes	11.9	200		-	2	1	-	X	X	-	X	Yes	No	
EGA	Ethylene Glycol Monoethyl Ether Acetate	L	No	Yes	51	25		U	2	1	-	X	-	-	X	Yes	No	Low toxicity [5]
ENE	Ethylene Glycol Monomethyl Ether	L	No	Yes	23	25		U	U	U	-	-	-	-	X	Yes	Yes	Toxic by inhalation & ingestion [5]
EDX	Ethylene Oxide	G	No	Yes	>760	50		2	2	3	-	-	X	X	-	Yes	Yes	
EDA	Ethylenediamine	L	No	Yes	29	10		3	3	3	-	-	-	-	X	Yes	No(ACE)	
EDT	Ethylenediamine Tetracetic Acid	S	No	No	<0.25	DNA		1	-	1	X	-	-	-	-	Yes	No	
ETI	Ethylenimine	L	No	Yes	362	5/30 min		3	3	3	-	-	-	X	-	Yes	No	Low toxicity [5]
ENA	Ethylhexaldehyde	L	No	Yes	5.7	DNA		(3)	1	(3)	-	-	X	X	-	Yes	No	Toxic rating as aldehydes
EAI	2-Ethylhexyl Acrylate	L	No	Yes	0.43	DNA		(3)	-	(3)	-	-	X	X	-	Yes	No	Toxic rating as acrylic acid
ENT	Ethylhexyl Tallate	L	No	Yes	DNA	DNA					-	-	-	-	-	Yes	Yes	Not harmful
ENB	Ethylidenenorbornene	L	No	Yes	11.3	0.2[5]					-	-	-	-	-	Yes	Yes	Toxic [5]
EPS	Ethylphenyl Dichlorosilane	L	Yes	Yes	0.57	DNA		3	-	3	-	-	X	X	-	Yes	No	
ETS	Ethyltrichlorosilane	L	Yes	Yes	61	DNA		3	-	3	-	-	X	X	-	Yes	No	
FAC	Ferric Chloride	S	No	Yes	<0.25	DNA		U	U	U	-	-	-	-	-	Yes	Yes	Low toxicity
FAO	Ferric Ammonium Oxalate	S	No	No	<0.25	1* (Fe)					-	-	-	-	-	Yes	Yes	Moderately toxic [5], burns skin
FCL	Ferric Chloride	S	Yes	No	<0.25	1* (Fe)		-	-	1*	-	-	X	X	1	Yes	Yes	Water reacts to HCl, strong irritant skin & tissue [5]
FX	Ferric Fluoride	S	No	-	-	2.5 (F)		(3)	-	(3)	-	-	X	X	-			Toxic strong irritant; toxic rating as fluoride
FCP	Ferric Glycerophosphate	S	No	No	<0.25	1* (Fe)		1	-	2	X	-	-	-	X	Yes	Yes	Used in pharmaceuticals [5]
FNT	Ferric Nitrate	S	No	Yes	<0.25	1* (Fe)					-	-	-	-	-	Yes	Yes	
FSF	Ferric Sulfate	S	No	No	<0.25	1* (Fe)		-	-	1	X	-	-	-	X	Yes	Yes	
FAS	Ferrous Ammonium Sulfate	S	No	No	<0.25	1* (Fe)		-	-		X	-	-	-	X	Yes	Yes	Based on ferrous sulfate and ammonium sulfate
FEC	Ferrous Chloride	S	No	No	<0.25	1* (Fe)		-	-		X	-	-	-	X	Yes	Yes	Poisonous if inhaled, irritant to skin & tissue
FFB	Ferrous Fluoborate	L	-	-	DNA	0.098					-	-	-	-	-			
FOX	Ferrous Oxalate	S	No	No	<0.25	50 (Co)		-	-	3	-	-	X	X	-	Yes	Yes	Evokes CO on heating; toxic rating oxalates
FRS	Ferrous Sulfate	S	No	No	<0.25	DNA		2	-	1	X	-	-	-	X	Yes	Yes	Low toxicity
FXF	Fluorine	G	Yes	No	>750	1		3	-	3	-	-	X	X	-	No	PVC[18]	
FSL	Fluosilicic Acid	L	Yes	No	Fumes	DNA		3	-	3	-	-	-	-	-	No(PVC)	PVC[11]	Fuming liquid, high toxicity
FSA	Fluosulfonic Acid	L	Yes	No	6.0	DNA		3	-	3	-	-	X	X	-	No	No	
FMS	Formaldehyde Solution	L	No	Yes	4.6	2		3	-	2	-	-	X	X	-	Yes	Yes	Avoid skin contact [5]
FMA	Formic Acid	L	No	Yes	77	5		2	-	3	-	-	X	X	-	Yes	Yes	
FUM	Fumaric Acid	S	No	Yes	<0.1	DNA		-	-	1	X	-	-	-	-	Yes	Yes	

C	CN	S	WR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAX-TOXIC HAZARD RATING			LEVELS OF PROTECTION					MATERIAL COMPAT- IBILITY [10]		NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	MS	B	P	
FFA	Furfural	L	No	Yes	5.1	5	15	2	2	2	-	X	X	-	X	Yes	Yes	Dangerous to eyes [8] Toxic by inhalation [5], but used as food additive Mild irritant
FAL	Furfuryl Alcohol	L	No	Yes	0.16	5	10	-	-	-	-	X	-	-	X	Yes	Yes	
GLA	Galllic Acid	S	No	Yes	<0.11	DNA		-	-	-	X	-	-	-	X	Yes	(PVC) [11]	
GOC	Gas Oil: Cracked	L	No	Yes	Propane	500/30min		(2)	-	(1)	-	X	X	-	X	No		Toxic rating as kerosene
GAK	Gas Blending Stocks: Alkalates	L	No	Yes	Hexane	500/30min		(1)	-	(1)	-	X	-	-	X	No		Toxic rating as hexane
GRF	Gas Blending Stocks: Reformates	L	No	Yes	Hexane	500/30min		(2)	-	(2)	-	X	X	-	X	No		Toxic rating as hexane
GAT	Gasoline, Automotive (4.23 G PB/Gal)	L	No	Yes	Propane	500/30min		(2)	(0)	(0)	-	X	X	-	X	No		Toxic rating as propane
GAV	Gasoline, Aviation 4.86 G PB/Gal	L	No	Yes	Butane	500/30min		(2)	(0)	(0)	-	X	X	-	X	No		Toxic rating as butane
GCS	Gasoline: Casinghead	L	No	Yes	Butane	500/30min		(1)	(U)	(U)	-	X	X	-	X	No		Irritates skin & eyes
GPL	Gasoline: Polymer	L	No	Yes	Pentane	500/30min		(2)	(1)	-	-	X	-	-	X	No		Toxic rating as pentane
GSR	Gasoline: Straight Run	L	No	Yes	Pentane	500/30min		(3)	(1)	(3)	-	X	-	-	X	No		Toxic rating as pentane
GTA	Glutaraldehyde, Solution	L	No	No	0.1	0.25*		-	-	-	-	-	-	-	-	-	-	Toxic rating as aldehydes
GCR	Glycerine	L	No	Yes	0.1	DNA		-	-	1	-	-	-	-	-	-	-	Low toxicity [5] Burns skin & eyes, glycidyl acrylate - Sax 3 Rating Highly toxic by inhalation, skin, ingestion
GCH	Glycidyl Methacrylate	L	No	Yes	<0.25	25		-	-	-	-	-	-	-	-	-	-	
GOS	Glyoxal, 40% Solution	L	Yes	Yes	~300	DNA		2	-	2	-	X	X	-	X	Yes	Yes	
HTC	Heptachlor	S	No	No	<0.25	0.5*		-	-	-	-	-	-	-	-	-	-	
HPT	Heptane	L	No	Yes	98	400	500	-	-	1	-	-	X	-	-	No	Yes	Narcotic high conc., irritates respiratory track
HTN	Heptanol	L	No	Yes	1.2	DNA		U	U	U	-	X	-	-	-	Yes	Yes	Low toxicity [5], not harmful
HTE	1-Heptene	L	No	Yes	103	DNA		1	-	-	-	X	-	-	-	No		Asphyxiant, effects as argon [8]
HCC	Hexachlorocyclopentadiene	L	No	No	0.26	0.1	0.3	3	1	0	-	-	X	-	-	-	-	Toxic rating as CCld, toxic [5] readily skin absorbed
HSS	Hexadecyl Sulfate, Sodium Salt	L	-	-	0.26	DNA		-	-	-	-	X	-	-	-	-	-	Similar to surfactants, cosmetics Irritates skin & eyes
HAC	Hexadecyltrimethylammonium Chloride	L	-	Yes	<0.25	DNA		(3)	1	(3)	-	-	X	X	-	Yes	Yes	Severe eye & skin damage on cont.
HAL	n-Hexaldehyde	L	No	Yes	~10	DNA		-	-	2	-	-	X	X	-	-	-	Toxic rating as aldehydes
HMD	Hexamethylenediamine	S	No	Yes	17	DNA		-	-	-	-	-	X	-	-	-	-	Poisonous if swallowed, strong skin irritant or skin exposed [5]
HPI	Hexamethyleneimine	L	No	Yes	1.0	DNA		U	U	U	-	-	X	X	-	-	-	Burns skin & eyes
HMT	Hexamethylenetetramine	S	No	Yes	<0.25	DNA		-	-	-	-	-	X	-	-	-	-	Same as HMD
HXA	Hexane	L	No	Yes	258	100	125	1	-	1	-	-	-	-	-	No	Yes	
HXM	Hexanol	L	No	Yes	39	DNA		-	-	-	-	-	X	-	-	Yes	Yes	Toxicity ~alcohols. Low
HXE	1-Hexene	L	No	Yes	310	500		2	-	2	-	X	X	-	X	No		Poisonous through skin
HAG	Hexylene Glycol	L	No	Yes	0.3	25		1	-	2	-	X	-	-	-	-	-	
HDZ	Hydrazine	L	No	Yes	29	0.1		3	3	3	-	-	X	X	-	Yes	Yes	
HCL	Hydrochloric Acid	L	Yes	No	362	5		3	-	3	-	-	-	-	-	Yes	Yes	
HFA	Hydrofluoric Acid	L	Yes	No	>760	3		3	-	3	-	-	X	X	-	No	PVC [11]	
HBR	Hydrogen Bromide	G	Yes	No	>760	3		3	-	3	-	-	X	X	-	Yes	Yes	
HDC	Hydrogen Chloride	G	Yes	No	>760	5		3	-	3	-	-	X	X	-	Yes	Yes	
HCN	Hydrogen Cyanide	G	Yes	Yes	>760	10	15	3	3	2	-	-	X	X	-	Yes	Yes	
HFX	Hydrogen Fluoride	G	Yes	No	>760	3		3	-	3	-	-	X	X	-	No	PVC [11]	
HPO	Hydrogen Peroxide	L	No	Yes	>760	1	2	3	-	3	-	-	X	X	-	Yes	Yes	
HDS	Hydrogen Sulfide	G	No	Yes	>760	10	15	3	-	3	-	-	X	X	-	Yes	Yes	
HXX	Hydrogen, Liquefied	L/G	No	Yes	>760	DNA		1	0	0	-	X	X	-	-	Yes	Yes	

C	CN	S	MR	F	VP	TLV (ppm or mg/m <sup>3</sup> )*		SAFETY HAZARD RATING			LEVELS OF PROTECTION				MATERIAL COMPATIBILITY (10)		NOTES	
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B		P
HDQ	Hydroquinone	S	No	Yes	0.11	2*		3	-	2	-	-	X	-	X	No(11) PVC(11)		Burns skin & eyes
HAI	2-Hydroxyethyl Acrylate (Inhibited)	L	-	Yes	<1.0	DNA					-	-	X	X	-			
HDA	Hydroxylamine	L	No	Yes	<10	DNA		2	-	2	X	-	-	-	-			
HAS	Hydroxylamine Sulfate	S	No	Yes	DNA	DNA		(3)	-	(3)	-	-	X	X	-	PPVC(18)	(PVC)	Toxic rating as sulfuric acid
HPA	Hydroxypropyl Acrylate	L	-	Yes	<20	DNA					-	-	X	X	-			Acrylates-generally high toxicity
HPM	Hydroxypropyl Methacrylate	L	No	Yes	<1	DNA		3	-	2	-	X	-	-	X	Yes	Yes	Burns skin & eyes
IAA	Isobutyl Alcohol	L	No	Yes	8.3	100		1	0	0	-	-	X	-	-	Yes	Yes	Low toxicity[5], burns eyes
IBT	Isobutane	G	No	Yes	>760	DNA					-	-	X	-	-			
IBA	Isobutyl Acetate	L	Yes	Yes	35	150		2	-	2	-	X	X	X	-	Yes	No	
IAB	Isobutyl Alcohol	L	No	Yes	26	50		2	-	3	-	X	X	X	-	Yes	Yes	
IAM	Isobutylamine	L	No	Yes	244	5		2	-	-	-	-	X	X	-	Yes	No	
IBL	Isobutylene	L	-	Yes	>760	1000		-	-	-	-	-	X	-	-	Yes	Yes	Asphyxiant, nontoxic [5]
IBR	Isobutyric Acid	L	No	Yes	3.6	DNA		(1)	(1)	2	-	-	-	-	X	Yes	Yes	Toxic rating inhla. - Skin as butyric acid
IBN	Isobutyronitrile	L	No	Yes	43	22		(3)	(3)	(1)	-	-	X	X	-	Yes	No	Toxic rating as cyanide
IOD	Isodecyl Alcohol	L	-	Yes	0.9	DNA		(3)	(1)	(3)	-	-	X	X	-	Yes	No	Toxic rating as aldehydes
IDA	Isodecyl Alcohol	L	No	Yes	<0.4	DNA		(3)	(1)	(3)	-	-	X	X	-			Toxic rating as aldehydes
IAI	Isododecyl Acrylate (Inhibited)	L	No	Yes	<0.25	DNA		U	U	U	-	-	X	X	-	Yes	Yes	Same as IAI
ISA	Isododecyl Alcohol	L	No	Yes	<0.25	DNA		(1)	-	(1)	-	-	X	-	-	No	No	Alcohols generally low toxicity [5]
IHZ	Isohexane	L	No	Yes	362	DNA		-	-	-	-	-	X	-	-	Yes	Yes	Toxic rating as hexane; low toxicity
IOA	Isododecyl Alcohol	L	No	Yes	1.4	DNA		-	-	-	-	-	X	-	-	Yes	Yes	Low toxicity[5], alcohol
IPT	Isopentane	L	No	Yes	103	DNA		(1)	U	U	-	-	X	-	-	No	Yes	Low toxicity[5]; see pentane
IPH	Isophorone	L	No	Yes	1.0	(C) 5		3	-	2	-	-	X	-	-	Yes	Yes	
IPL	Isophthalic Acid	S	No	Yes	<0.25	DNA		1	-	1	X	-	-	X	-	Yes	Yes	
IPR	Isoprene	L	No	Yes	>760	DNA		2	-	2	-	-	X	-	-	No	No	
IAC	Isopropyl Acetate	L	No	Yes	103	250		2	-	1	-	X	X	X	-	Yes	No	
IPA	Isopropyl Alcohol	L	No	Yes	93	400		2	-	1	-	X	X	X	-	Yes	Yes	
IPE	Isopropyl Ether	L	No	Yes	242	250		2	-	3	-	-	X	X	-	Yes	Yes	
IPH	Isopropyl Mercaptan	L	-	Yes	<150	DNA		(3)	-	(3)	-	-	X	-	-	Yes	Yes	Toxic rating as mercaptan
IPC	Isopropyl Percarbonate	S	No	Yes	DNA	DNA		U	U	U	-	-	-	-	-	Yes	Yes	Legal name Diisopropylperoxy dicarbonate; unstable & stable forms; Flammable & corrosive fumes
IPP	Isopropylamine	L	No	Yes	>760	5.0		2	(1)	3	-	-	X	X	-	Yes	No	
IYA	Isovaleraldehyde	L	No	Yes	111	DNA		(3)	(1)	(3)	-	-	X	X	-	Yes	No	As aldehydes, low toxicity[5]
JPO	Jet Fuel: JP-1 (Kerosene)	L	No	Yes	5	200[9]		(2)	-	(1)	-	-	X	-	-	No(PVC) Yes(12)	Yes	As kerosene toxicity
JPT	Jet Fuel: JP-3	L	No	Yes	299	200[9]		(2)	-	(1)	-	-	X	-	-	No(Buna) Yes(11)	Yes	As kerosene toxicity
JPF	Jet Fuel: JP-4	L	No	Yes	145	200[9]		(2)	-	(1)	-	-	X	X	-	-	Yes	As kerosene
JPV	Jet Fuel: JP-5 (Kerosene, Heavy)	L	No	Yes	2	200[9]		(2)	-	(1)	-	-	X	X	-	-	Yes	As kerosene
KPE	Kerosene	L	No	-	-	DNA		(2)	-	(1)	-	-	X	-	-	-	Yes	As kerosene
KBS	Kerosene	L	No	Yes	5	200[9]		2	-	1	-	-	X	-	-	No(PVC) Yes(12)	Yes	
LTA	Lactic Acid	L	No	Yes	<0.1	DNA		-	-	2	-	-	X	-	-	Yes	Yes	
LLS	Latex, Liquid Synthetic	L	No	No	<0.25	DNA		-	-	2	-	-	X	-	-	Yes	Yes	Could contain ammonia [5]
LPO	Lauryl Peroxide	S	No	Yes	<0.03	DNA		3	-	3	-	-	X	-	-	Yes	Yes	

C	CN	S	WR	F	VP	TLV (PPM OR MG/M3)*		SAF-TOXIC HAZARD RATING				LEVELS OF PROTECTION				MATERIAL COMPATIBILITY (10)		NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P	
LPM	Lauryl Mercaptan	L	No	Yes	<0.03	DNA		(3)	-	(3)	-	-	X	X	-	Yes	Yes	As mercaptans
LAC	Lead Acetate	S	No	No	<0.25	0.15*(Pb)		3	-	0	-	-	X	X	-	Yes	Yes	Suspected carcinogen as lead(8); absorbed via skin, inhalation(5)
LAR	Lead Arsenate	S	No	No	<0.25	0.15*(Pb)		(3)	-	(2)	-	-	X	X	-	Yes	Yes	As arsenic compounds; suspected carcinogen(8)
LCL	Lead Chloride	S	No	No	-	0.15*(Pb)		3	0	0	-	-	X	X	X			As fluoride, as fluoroborate
LFB	Lead Fluoroborate	L	-	-	DNA			(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	As fluorides, toxic rating, strong irritant [5]
LTR	Lead Fluoride	S	No	No	<0.25	0.15*(Pb)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	As lead compds; toxic rating, strong irritant [5]
LID	Lead Iodide	S	No	No	<0.25	- [9]		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	As nitrate(2-inhalation) as lead (3-inhalation)
LNT	Lead Nitrate	S	No	Yes	<0.25	0.15*(Pb)		2(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	As lead compds; absorbed by skin
LSA	Lead Stearate	S	No	Yes	-	DNA		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	As lead compds; absorbed by skin
LSF	Lead Sulfate	S	No	No	-	0.15*(Pb)		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	As lead compds; toxic rating
LTT	Lead Tetraacetate	S	-	Yes	<0.25	0.15*(Pb)		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	As lead compds; absorbed by skin(5)
LTC	Lead Thiocyanate	S	No	No	<0.25	0.15*(Pb)		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	As lead compds; toxic rating, decomp. hot water
LTS	Lead Thiosulfate	S	No	-	-	0.15*(Pb)		(3)	(0)	(0)	-	-	X	X	-			" " " "
LTU	Lead Tungstate	S	No	Yes	<0.03	0.15*(Pb)		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	Alcohols, low toxicity [5]
LAL	Linear Alcohols (12-15 Carbons)	L	No	Yes	>760	DNA		1	0	0	-	-	X	X	-	Yes	Yes	Asphyxiant
LNG	Liquefied Natural Gas	L/G	No	Yes	>760	DNA		1	0	0	-	-	X	X	-	Yes	Yes	Asphyxiant
LPG	Liquefied Petroleum Gas	L	No	Yes	>760	1000		(3)	(0)	(0)	-	-	X	X	-	Yes	Yes	Toxic rating as lead compound
LTH	Litharge	S	No	No	<0.25	0.2*		(2)	(2)	(2)	-	-	X	X	-	Yes	Yes	Toxic rating as lithium compound
LAM	Lithium Aluminum Hydride	S	Yes	Yes	Yes	DNA		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Carcinogen [8], toxic rating as chromium compound
LBC	Lithium Bichromate	S	No	-	-	DNA		(3)	-	(3)	-	-	X	X	-			Carcinogen. Toxic rating as Chromium compound
LCH	Lithium Chromate	S	No	-	-	DNA		(3)	-	(3)	-	-	X	X	-			Toxic rating as lithium compound
LHD	Lithium Hydride	S	Yes	Yes	<0.25	0.0705		(2)	-	(2)	-	-	X	X	-	Yes	Yes	Low toxicity
LTM	Lithium Metal	S	Yes	Yes	<0.25	DNA		(2)	-	(2)	-	-	X	X	-	Yes	Yes	Toxic rating as magnesium compd.
MGX	Magnesium	S	Yes	Yes	<0.25	DNA		(2)	-	(1)	-	-	X	X	-			
MPG	Magnesium Perchlorate	S	No	Yes	<0.25	DNA		2	-	2	-	-	X	X	-	Yes	Yes	Cholinesterase inhibitor, inhal. & skin absorp. [5]
MLT	Malathion	L	No	Yes	<0.25	0.00077		2	-	3	-	-	X	X	-	Yes	Yes	
MLI	Maleic Acid	S	No	Yes	<0.25	DNA		2	-	3	-	-	X	X	-	Yes	Yes	
MLA	Maleic Anhydride	S	No	Yes	0.6	0.25/1*		3	-	3	-	-	X	X	-	Yes	Yes	
MLH	Maleic Hydrazide	S	No	Yes	<0.1	DNA		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as hydrazine
MAT	Mercuric Acetate	S	No	No	DNA	0.05*(Hg)		(3)	(2)	(3)	-	-	X	X	-	Yes	Yes	Toxic rating, organic Hg compd.
MCC	Mercuric Ammonium Chloride	S	No	No	DNA	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Skin absorp. [5]
MRC	Mercuric Chloride	S	No	No	0.00047	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	" " " "
MCH	Mercuric Cyanide	S	No	No	DNA	0.05*(Hg)		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as cyanide
MID	Mercuric Iodide	S	No	No	<0.25	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Toxic rating-inorg. Hg. compd.
MNT	Mercuric Nitrate	S	No	Yes	DNA	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	" " " "
MDX	Mercuric Oxide	S	No	No	<0.25	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	" " " "
MRS	Mercuric Sulfate	S	Yes	-	0.05*(Hg)	0.15*		(3)	-	(3)	-	-	X	X	-	(PVC)	Yes	Toxic rating -inorg. Hg. compd.
MSF	Mercuric Sulfide	S	No	Yes	<0.25	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	[12]	Yes	" " " "
MRT	Mercuric Thiocyanate	S	No	-	-	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Toxic rating-org. Hg compounds
MRR	Mercurous Chloride	S	No	No	<0.25	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Toxic rating-inorg. Hg compounds

C	CN	S	MR	F	VP	TLV (ppm or mg/m <sup>3</sup> )		SAFETY HAZARD RATING				LEVELS OF PROTECTION						MATERIAL COMPATIBILITY (10)	NOTES
						TWA	STEL	IN	SA	IR	RESPIRATORY CLOTHING								
											PF	CC	AS	SS	NS	B	P		
MNH	Mercurous Nitrate	S	No	Yes	DNA	0.05*(Hg)		(3)	-	(3)	-	-	-	-	-	Yes	Yes	Toxic rating-inorg. Hg compds. (shock sens.)	
MNR	Mercury	L	No	No	0.005	0.05*(Hg)		(3)	-	(3)	-	-	X	X	-	Yes	Yes		
MNO	Methyl Oxide	L	No	Yes	20	25		-	-	3	-	-	X	X	-	Yes	Yes	Toxicity:irr. inhal, skin [5]	
MNL	Methyl Chloride	L	No	Yes	220	DNA		2	-	2	-	-	X	X	-	No	No		
MTH	Methane	G	No	Yes	>760	DNA		1	0	0	-	-	-	-	-	Yes	Yes	Toxic rating as methane arsenic acid	
MTH	Methane Arsonic Acid, Sodium Salt	S	No	No	DNA	DNA		(1)	-	(1)	-	-	-	-	-	Yes	Yes	Less toxic than DOT [5]	
MTC	Methoxychlor	S	No	No	<0.25	0.65		1	-	1	-	-	-	-	-	Yes	Yes	Animal test indicate minimal toxicity:inhal, toxic [5]	
MTP	Methyl Acetylene, Propadiene Mixture	L/G	No	Yes	>760	1000		-	-	-	-	-	-	-	-	No	No	Asphyxiant	
MTT	Methyl Acetate	L	No	Yes	360	200	250	2	2	1	-	X	X	-	-	No	No	Poisonous through skin [5]	
MAL	Methyl Alcohol	L	No	Yes	237	200	250	2	2	1	-	X	X	-	-	Yes	Yes	Poisonous through skin [5]	
MAL	Methyl Amyl Acetate	L	No	Yes	1.0	DNA		2	-	1	-	X	X	-	-	Yes	No		
MAL	Methyl Amyl Alcohol	L	No	Yes	14.0	25	40	3	3	3	-	-	X	X	-	Yes	Yes	Poisonous through skin [5]	
MTB	Methyl Bromide	L/G	No	Yes	>760	15		3	-	3	-	-	X	X	-	No	No		
MTC	Methyl Chloride	G	No	Yes	740	100	125	3	-	1	-	-	X	X	-	Yes [14]	No		
MCH	Methyl Chloroformate	L	Yes	Yes	220	DNA		3	-	3	-	-	X	X	-	No	No		
MCS	Methylchlorosilane	L	Yes	Yes	>750	5(HCl)		3	-	3	-	-	X	X	-	Yes	No		
MEK	Methyl Ethyl Ketone	L	No	Yes	165	200	300	2	-	1	-	X	X	-	-	Yes	No	Skin, eyes, nose, throat irritant	
MEF	Methyl Formate	L	No	Yes	660	1000 [9]		2	-	2	-	-	X	X	-	Yes	Yes	As hydrazine	
MFM	Methyl Formate	L	No	Yes	>760	100	150	3	-	2	-	-	X	X	-	No	No		
MEZ	Methyl Hydrazine	L	No	Yes	95	0.2 [9]		(3)	(3)	(3)	-	-	-	-	-	Yes	Yes		
MIC	Methyl Isobutyl Carbino	L	No	Yes	14	25	40	3	3	3	-	-	X	X	-	Yes	Yes	Irritates eyes, skin; prolonged contact blisters skin	
MIC	Methyl Isobutyl Ketone	L	No	Yes	38	100	125	(3)	-	(2)	-	-	X	X	-	Yes	No		
MPK	Methyl Isopropenyl Ketone (Inhibited)	L	-	Yes	79	100 [9]		U	U	U	-	-	X	X	-	Yes	No		
MPC	Methyl Mercaptan	L/G	No	Yes	>760	0.5		(2)	-	(2)	-	-	X	X	-	Yes	Yes		
MPL	Methyl Methacrylate	L	No	Yes	77	100	125	1	-	1	-	-	-	-	-	Yes	Yes	As parathion, cholinesterase inhibitor, 8 day half life	
MPT	Methyl Parathion	S	Yes	Yes	<0.01	0.2*	0.6*	(3)	(3)	U	-	-	X	X	-	Yes	Yes	Skin irritant & lachrymator, cause skin burn	
MVK	Methyl Vinyl ketone	L/G	No	Yes	153	DNA		-	-	-	-	-	X	X	-	No	No		
MWK	Methyl-n-Butyl Ketone	L	No	Yes	36	100 [9]		3	-	2	-	-	X	X	-	Yes	No		
MAM	Methyl Acrylate	L	No	Yes	155	10		3	3	3	-	-	X	X	-	Yes	Yes	As monomethylamine	
MTA	Methylamine	G	No	Yes	>760	10		(3)	-	(3)	-	-	X	X	-	Yes	No	Poisonous if swallowed or skin exposed	
MMA	n-Methylamine	L	No	Yes	1.2	2 [9]		3	-	-	-	-	X	X	-	Yes	Yes	Eyes & skin irritant & narcotic in high concentrations	
MCT	Methylcyclopentadienyl Manganese Tricarbonyl	L	No	-	0.2	0.1 [9]	0.3	U	U	U	-	-	-	-	-	Yes	Yes	As pyridine	
MCP	Methylcyclopentadiene	L	No	Yes	2.28	DNA		U	U	U	-	-	-	-	-	No	No	Highly toxic irritant, corrosive very corrosive (like ammonia), highly toxic irritant	
MEP	Methylcyclopentadiene Dichloride, Anhydrous	L	No	Yes	5	DNA		(1)	(2)	(2)	-	-	-	-	-	Yes	Yes		
MPT	1-Methylpyrrolidone	L	No	Yes	0.9	DNA		U	U	U	-	-	X	X	-	Yes	No		
MOR	Methylstyrene, Alpha	L	No	Yes	5.4	100		2	-	2	-	-	X	X	-	Yes	Yes	As chlorosilane	
MOS	Methyltrichlorosilane	L	No	Yes	294	5 (HCl)		(3)	U	(3)	-	-	X	X	-	No	No		
MMS	Mineral Spirits	L	No	Yes	6	200		2	-	1	-	-	X	X	-	Yes	No		
MEX	Mirex	S	No	-	-	DNA		-	-	-	-	-	X	X	-	Yes	Yes	Highly toxic stomach insect [8]	

C	CN	S	HR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAFETY RATING		LEVELS OF PROTECTION				MATERIAL COMPATIBILITY [10]		NOTES		
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY		CLOTHING			B	P
												CC	AS	SS	NS			
MTD	Molybden Trioxide	S	No	No	DNA	5*(Mn)[9]	-	-	1	X	-	-	-	-	Yes	Yes	Refrigerant; liquid can cause frostbite [8]	
MCA	Monochloroacetic Acid	S	No	Yes	0.9	DNA	2	-	2	X	-	-	-	-	Yes	Yes		
MCF	Monochlorodifluoromethane	G	No	No	>760	1000	2	U	U	-	-	X	X	-	Yes	Yes		
MEA	Monoethanolamine	L	No	Yes	1.1	3	2	-	2	-	-	X	X	-	Yes	No(PVC)		
MPA	Monoisopropanolamine	L	No	Yes	2.3	5[9]	U	U	U	-	-	-	-	-	Yes	No	Toxic by inhal. & ingestion; irritates stomach tissue [5]	
MPL	Morpholine	L	No	Yes	26	20	2	2	2	-	-	X	X	-	Yes	No		
MEA	Motor Fuel Antiknock Compds. (Pb Alkyls)	L	No	Yes	0.67	0.1(Pb)	(3)	-	-	-	-	-	-	-	Yes	No(PVC)	As lead compds; Pb alkyls absorbed by skin [5]	
NAB	Nabam	S	No	No	<0.25	DNA	-	-	-	-	-	-	-	-	Yes	Yes		Recog. carcinogen; narcotic at high conc. skin & mucous irritant
NLD	Naled	S	No	-	~1	DNA	U	U	U	-	-	-	-	-	Yes	Yes	Cholinesterase inhibitors [5]	
NCT	Naphtha: Coal Tar	L	No	Yes	6.7	100	3	3	2	-	-	-	-	-	No(14)	Yes		Neoprene
NSV	Naphtha: Solvent	L	No	Yes	6.7	200	3	3	2	-	-	-	-	-	Nitriles	(PVC)[18]	Standard conditions As cyclopentadiene (an assoc. compd.) Recognized carcinogen	
NSS	Naphtha: Stoddard Solvent	L	No	Yes	6.7	200	2	-	1	-	-	-	-	-	No"	No"		
NVM	Naphtha: VM P (75 Naphtha)	L	No	Yes	6.7	500/30 min	2	-	2	-	-	-	-	-	No	No	Low toxicity; narcotic in high conc. [5]; eye, nose, throat irrit. As Ni compd; recog. carcinogen As Ni compounds	
NTM	Naphthalene, Molten	S	Yes	Yes	8980°C	10/50*	2	2	2	X	X	-	-	-	No(11)	Yes		
NTI	Naphthalenic Acid	S	No	Yes	DNA	1	(2)	-	-	-	-	-	-	-	Yes	Yes	Recognized carcinogen	
NAO	Naphthylamine	S	No	Yes	~0.01	DNA	3	3	2	-	-	-	-	-	Yes	Yes		As Ni compounds
NHX	Neohexane	L	-	Yes[5]	~700	DNA	U	U	U	-	-	-	-	-	Yes	Yes	Recognized carcinogen As Ni compd; toxic rating, carcinogen As cyanides; recog. carcinogen Toxic rating as fluocides	
NKA	Nickel Acetate	S	No	No	<0.25	1*(Ni)[9]	(3)	-	(1)	-	-	-	-	-	Yes	Yes		As Ni compd; toxic rating, carcinogen
NAS	Nickel Ammonium Sulfate	S	No	No	<0.25	"	(3)	-	(1)	-	-	-	-	-	Yes	Yes	As cyanides; recog. carcinogen Toxic rating as fluocides	
NBR	Nickel Bromide	S	No	No	<0.25	"	(3)	-	(1)	-	-	-	-	-	Yes	Yes	As Ni compounds	
NKC	Nickel Carbonyl	L	No	Yes	634	"	3	-	-	-	-	-	-	-	Yes	Yes	Recognized carcinogen	
NCL	Nickel Chloride	S	No	No	<0.25	"	(3)	-	(1)	-	-	-	-	-	Yes	Yes	As Ni compd; toxic rating, carcinogen	
RCN	Nickel Cyanide	S	No	No	DNA	DNA	(3)	(3)	(1)	(3)	-	-	-	-	Yes	Yes	As cyanides; recog. carcinogen Toxic rating as fluocides	
NFB	Nickel Fluoborate	L	-	-	DNA	DNA	(3)	(3)	(3)	-	-	-	-	-	Yes	Yes	As Ni compounds	
NFM	Nickel Formate	S	No	-	DNA	0.12[9]	(3)	-	(1)	-	-	-	-	-	Yes	Yes	Toxic rating as nickel compd, carcinogen	
NKH	Nickel Hydroxide	S	No	-	<0.25	1*(Ni)[5]	(3)	-	(1)	-	-	-	-	-	Yes	Yes	" " " " " "	
NMT	Nickel Nitrate	S	No	No	<0.25	1*(Ni)[9]	(3)	-	(1)	-	-	-	-	-	Yes	Yes	" " " " " "	
NKS	Nickel Sulfate	S	No	No	<0.25	"	(3)	-	(1)	-	-	-	-	-	Yes	Yes	" " " " " "	
NIC	Nicotine	L	No	Yes	~0.25	0.069[9]	3	3	2	-	-	-	-	-	Yes	Yes	As nicotine; toxic rating	
NCS	Nicotinic Sulfate	S	No	No	<0.25	DNA	(3)	(3)	(2)	-	-	-	-	-	Yes	Yes	Herbicide[5]; inhal. poison, skin, eye irritant	
NIL	Nitralin	S	No	-	<0.25	DNA	3	-	3	-	-	-	-	-	No(Yes)	(PVC)[11]	Confirmed carcinogen in rats and mice [5] As p-Nitroaniline, toxic rating	
NAC	Nitric Acid	L	Yes	No	82	2	3	-	3	-	-	-	-	-	Yes	Yes		As p-Nitroaniline, toxic rating
NTX	Nitric Oxide	G	Yes	No	>760	25	35	3	-	3	-	-	-	-	Yes	Yes	Confirmed carcinogen in rats and mice [5]	
NMA	Nitrotetraacetic Acid and Salts	S	No	Yes	<0.25	DNA	3	-	3	-	-	-	-	-	Yes	Yes	As p-Nitroaniline, toxic rating	
NTA	2-Nitroaniline	S	No	Yes	~0.25	1/6*	(3)	(3)	(u)	-	-	-	-	-	Yes	Yes	Confirmed carcinogen in rats and mice [5]	
NAL	4-Nitroaniline	S	No	Yes	<0.01	1/6*	(3)	(3)	(u)	-	-	-	-	-	Yes	Yes	Confirmed carcinogen in rats and mice [5]	
MTB	Nitrobenzene	L	No	Yes	0.7	1	2	3	3	U	-	-	-	-	No	No(ACE)	As nitric oxide, toxic rating	
NTE	Nitroethane	L	No	Yes	38	100	150	2	-	2	-	-	-	-	Yes	Yes		As nitric oxide, toxic rating
NOX	Nitrogen Dioxide	L/G	Yes	No	>760	5 [9]		(3)	-	(3)	-	-	-	-	No	No	As nitric oxide, toxic rating	
NXX	Nitrogen Liquefied	L	Yes	No	>760	3x10 [5]		-	-	-	-	-	-	-	Yes	Yes	Asphyxiant, component of air	

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAFETY HAZARD RATING		LEVELS OF PROTECTION				MATERIAL COMPATIBILITY		NOTES		
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY		CLOTHING			B	P
												CC	AS	SS	NS			
NTP NTP NTP NTP	Nitromethane	L	No	Yes	82	100	150	3	(U)	2	-	-	X	-	X	Yes	Yes	No appreciable harm to skin, eyes
	Nitrophenol	S	No	Yes	0.5	DNA	DNA	(3)	(U)	(U)	-	-	X	-	X	Yes	Yes	As p-nitrophenol, toxic rating
	2-Nitrophenol	S	No	Yes	0.5	DNA	DNA	(3)	(U)	(U)	-	-	X	-	X	Yes	Yes	-
	4-Nitrophenol	S	No	Yes	0.5	DNA	DNA	(3)	(U)	(U)	-	-	X	-	X	Yes	Yes	-
NTP NTP NTP NTP	2-Nitropropane	L	No	Yes	27	25		2	-	1	-	-	X	X	-	Yes	Yes	Carcinogen, MIOSH Rpt. 1978
	Nitrosyl Chloride	L/G	Yes	No	760	1		(3)	-	(3)	-	-	X	X	-	Yes	Yes	Toxic rating as p-nitrotoluene
	o-Nitrotoluene	L	No	Yes	0.5	5		3	3	2	-	-	X	X	-	-	-	Poisonous via skin
	p-Nitrotoluene	S	No	Yes	0.5	5/30*		3	3	2	-	-	X	X	-	-	-	Poisonous via skin
NTP NTP NTP NTP	Nitrous Oxide	L/G	No	No	760	DNA		2	0	0	-	X	X	-	-	Yes	Yes	Asphyxiant
	Monane	L	No	Yes	10	200		2	-	-	-	X	X	-	-	Yes	Yes	Irritant to respiratory track,
	Nonane	L	No	Yes	0.2	DNA		U	U	U	-	X	-	-	X	Yes	Yes	narcotic
	Nonene	L	No	Yes	11.4	DNA		U	U	U	-	X	-	-	X	Yes	Yes	Irritates skin, eyes & throat
NTP NTP NTP NTP	1-Monene	L	No	Yes	11.4	DNA		-	-	-	-	-	-	-	-	Yes	Yes	Wetting agent, irritates eyes,
	Monyl Phenol	L	No	Yes	0.1	DNA		3	3	3	-	X	X	-	-	Yes	No	Target, skin
	Octane	L	No	Yes	28	300		2	0	0	-	X	X	-	-	No	Yes	Toxic rating as phenol
	Octanol	L	No	Yes	0.3	DNA		-	-	-	-	X	-	-	-	Yes	Yes	Asphyxiant, narcotic in high conc.
NTP NTP NTP NTP	1-Octene	L	No	Yes	33	DNA		U	U	U	-	-	X	-	-	Yes	Yes	Low toxicity
	Octyl Epoxy Gallate	L	-	-	0.45	DNA		-	-	-	-	-	-	-	-	Yes	Yes	Unsaturated straight chain
	Oil, Edible: Castor	L	No	Yes	5.1	DNA		-	-	-	-	-	-	-	-	Yes	Yes	hydrocarbon [5]
	Oil, Edible: Coconut	L	No	Yes	DNA	DNA		-	-	-	-	-	-	-	-	Yes	Yes	
NTP NTP NTP NTP	Oil, Edible: Cottonseed	L	No	Yes	5.1	DNA		0	0	0	-	-	-	-	-	Yes	Yes	Non-toxic [5] but suspected
	Oil, Edible: Fish	L	No	Yes	5.1	DNA		-	-	-	-	-	-	-	-	Yes	Yes	carcinogen [2]
	Oil, Edible: Lard	L	No	Yes	5.1	DNA		-	-	-	-	-	-	-	-	Yes	Yes	-
	Oil, Edible: Olive	L	No	Yes	DNA	DNA		-	-	-	-	-	-	-	-	Yes	Yes	-
NTP NTP NTP NTP	Oil, Edible: Palm	L	No	Yes	DNA	DNA		0	0	1	-	-	-	-	-	Yes	Yes	
	Oil, Edible: Peanut	L	No	Yes	5.1	DNA		U	U	U	-	-	-	-	-	Yes	Yes	
	Oil, Edible: Safflower	L	No	Yes	DNA	DNA		U	U	U	-	-	-	-	-	Yes	Yes	
	Oil, Edible: Soybean	L	No	Yes	5.1	DNA		-	-	-	-	-	-	-	-	Yes	Yes	
NTP NTP NTP NTP	Oil, Edible: Tallow	L	No	Yes	DNA	DNA		-	-	-	-	-	-	-	-	Yes	Yes	
	Oil, Edible: Vegetable	L	No	Yes	5.1	DNA		-	-	-	-	-	-	-	-	Yes	Yes	
	Oil, Fuel: No. 1 (Kerosene)	L	No	Yes	5.1	200		(2)	-	(1)	-	X	X	-	X	No	Yes	Toxic rating as kerosene
	Oil, Fuel: No. 1-D	L	No	Yes	5.1	200		(2)	-	(1)	-	X	X	-	X	No	Yes	Toxic rating as kerosene
NTP NTP NTP NTP	Oil, Fuel: No. 2	L	No	Yes	5.1	200		(2)	-	(1)	-	X	X	-	X	No	Yes	Diesel oil, recognized carcinogen
	Oil, Fuel: No. 2-D	L	No	Yes	5.1	200		(2)	-	(1)	-	X	X	-	X	No	Yes	(8), toxic rating as kerosene
	Oil, Fuel: No. 4	L	No	Yes	5.1	200		U	U	U	-	X	X	-	X	No	Yes	Toxic rating as kerosene
	Oil, Fuel: No. 5	L	No	Yes	5.1	200		U	U	U	-	X	X	-	X	No	Yes	Heavier distillate than 1 & 2
NTP NTP NTP NTP	Oil, Fuel: No. 6	L	No	Yes	5.1	200		U	U	U	-	X	X	-	X	No	Yes	Heavy oil
	Oil, Misc: Absorption	L	No	Yes	5.1	DNA		U	U	U	-	X	X	-	X	No	Yes	Irritating to skin & eyes
	Oil, Misc: Coal Tar	L	No	Yes	5.1	DNA		1	-	1	-	X	X	-	X	No	Yes	Poison if swallowed or skin exposed,
	Oil, Misc: Croton	L	No	Yes	DNA	DNA		-	-	2	-	-	X	X	-	No	Yes	strong skin irritant [5]

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAX-TOXIC HAZARD RATING				LEVELS OF PROTECTION					MATERIAL COMPATIBILITY (10)		NOTES
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	NS	B	P	RESPIRATORY	
OLS	Oil, Misc: Linseed	L	No	Yes	DNA	DNA	-	-	1	-	-	X	-	-	X	Yes	Yes	Nonotoxic[5];not harmful [5]	
OLB	Oil, Misc: Lubricating	L	No	Yes	5.1	DNA	U	U	U	-	-	Y	-	-	X	No (PVC)[12]	Yes	Irritates eyes & skin [9]	
OLM	Oil, Misc: Mineral	L	No	Yes	5.1	DNA	U	U	U	-	-	X	-	-	X	"	"	Irritates eyes & skin; recog- nized carcinogen [8]	
OLN	Oil, Misc: Mineral Seal	L	No	Yes	5.1	200	(2)	-	(1)	-	-	X	X	-	X	No	No	Toxic rating as kerosene	
OMT	Oil, Misc: Motor	L	No	Yes	5.1	DNA	-	U	U	U	-	-	-	-	X	Yes	Yes	Irritates eyes & skin [9]	
OMF	Oil, Misc: Neatsfoot	L	No	Yes	5.1	DNA	U	U	U	-	-	-	-	-	X	No	No	Not harmful	
OPT	Oil, Misc: Penetrating	L	No	Yes	5.1	DNA	(2)	-	(1)	-	-	X	X	-	X	No	No	Irritates eyes & skin [9]	
ORG	Oil, Misc: Range	L	No	Yes	5.1	200												Toxic rating as kerosene	
ORS	Oil, Misc: Resin	L	No	Yes	5.1	DNA	U	U	U	U						Yes	Yes	Exposure data not available	
ORD	Oil, Misc: Road	L	No	Yes	5.1	5*	-	-	-	-						No	No	Burns skin & eyes [9]	
ORN	Oil, Misc: Rosin	L	No	Yes	5.1	DNA	U	U	U	U						Yes	Yes	Exposure data not available	
OSP	Oil, Misc: Sperm	L	No	Yes	5.1	DNA	U	U	U	U						Yes	Yes	Carcinogen suspect[8], exposure data not available [9]	
OSD	Oil, Misc: Spindle	L	No	Yes	5.1	DNA	U	U	U	U	-	X	-	-	X	No	No	Irritates skin & eyes [9]	
OSY	Oil, Misc: Spray	L	No	Yes	5.1	200	-	-	-	-	-	X	-	-	X	No	No	Irritates skin & eyes [9]	
OTL	Oil, Misc: Tall	L	No	Yes	5.1	DNA	-	-	1	-	-	X	-	-	X	No	No	Low toxicity [5]	
OTN	Oil, Misc: Tanners	L	No	Yes	5.1	DNA	-	-	-	-	-	-	-	-	-	No	No	Exposure data not available [5,8,9]	
OTF	Oil, Misc: Transformer	L	No	Yes	5.1	DNA	U	U	U	U	-	X	-	-	X	No	No	Irritates skin & eyes, chlori- nated biphenyls or mineral oil	
OTB	Oil, Misc: Turbine	L	No	Yes	5.1	0.43	U	U	U	U	-	X	-	-	X	No	No	Irritates eyes,nose,throat,skin[5]	
OCF	Oil, Misc: Clarified	L	No	Yes	5.1	DNA	1	-	-	-	-	-	-	-	-	No	No	Data not available [5,8]	
OIL	Oil: Crude	L	No	Yes	5.1	DNA	-	-	-	-	-	-	-	-	-	No	No	Data not available [5,8]	
OOS	Oil: Diesel	L	No	Yes	5.1	DNA	2	-	-	?	-	X	X	-	X	No (Nitrile)	Yes	Monotoxic [5]	
OLA	Oleic Acid	L	No	Yes	<0.25	DNA	-	-	1	-	-	-	-	-	-	Yes	Yes	Toxic rating as oleic acid	
OAP	Oleic Acid, Potassium Salt	S	No	No	<0.25	DNA	-	-	(1)	X	-	-	-	-	-	Yes	Yes	Toxic rating as oleic acid [8], low toxicity [5]	
OAC	Oleic Acid, Sodium Salt	S	No	No	<0.25	DNA	-	-	(1)	X	-	-	-	-	-	Yes	Yes	Toxic rating as oleic acid [8], low toxicity [5]	
OLM	Oleum	L	Yes	No	>1.1	1*	3	U	3	3	-	-	X	X	-	No (PVC)	(11)	Decomposes on standing to aldehydes	
OXA	Oxalic Acid	S	No	Yes	<0.005	1*	3	-	-	3	-	-	X	X	-	Yes	Yes	Decomposes on standing to aldehydes	
OXY	Oxygen, Liquid	L	No	No	>760	DNA	2	-	-	-	-	-	-	-	-	Yes	Yes	Decomposes on standing to aldehydes	
PFA	Pentafluoroethane	S	Yes	Yes	22	5	2	-	2	2	X	X	-	-	X	Yes	Yes	Decomposes on standing to aldehydes	
POH	Paraldehyde	L	No	Yes	23	DNA	2	-	-	1	-	X	X	-	X	Yes	Yes	Decomposes on standing to aldehydes	
PTO	Parathion	L	No	No	0.001	0.00077	3	3	3	U	-	-	X	X	-	Yes	Yes	Decomposes on standing to aldehydes	
PTB	Pentaborane	L	No	Yes	<150	0.005	3	-	3	3	-	-	X	X	-	No	No	Decomposes on standing to aldehydes	
PCP	Pentachlorophenol	S	No	No	<0.25	0.5*	3	3	3	3	-	-	X	X	-	Yes	Yes	Decomposes on standing to aldehydes	
PDC	Pentadecanol	L	No	Yes	<0.25	10*	U	U	U	U	-	X	-	-	X	Yes	Yes	Linear alcohol;low toxicity[5]	
PET	Pentaerythritol	S	No	Yes	<0.25	DNA	-	-	-	-	-	-	-	-	-	Yes	Yes	Nuisance dust[5];not harmful[9]	
PTA	Pentene	L	No	Yes	>760	600	1	U	U	U	-	-	-	-	-	No	No	Marcotic in high concentration	
PTE	1-Pentene	L	No	Yes	>760	DNA	2	1	-	-	-	X	X	-	X	No	No	Asphyxiant	
PAA	Peracetic Acid	L	No	Yes	36.6	DNA	3	-	3	3	-	-	X	X	-	Yes	Yes	Unstable liquid;explodes with shock,heat & organics [5]	
PCL	Perchloric Acid	L	No	Yes	<0.25	DNA	3	-	3	3	-	-	X	X	-	Yes	Yes	Unstable liquid;explodes with shock,heat & organics [5]	
PCM	Perchloromethyl Mercaptan	L	Yes	Yes	<1.8	0.1	3	-	3	3	-	-	X	X	-	Yes	No	Mildly decomposes in moist air[5]	
PPL	Petrolatum	L	No	Yes	<0.25	DNA	U	U	U	U	-	-	X	X	-	Yes	Yes	Recognized carcinogen [8]	

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAX-TOXIC HAZARD RATING			LEVELS OF PROTECTION					MATERIAL COMPATIBILITY [10]		NOTES	
						THA	STEL	IN	SA	IR	PF	CC	AS	SS	MS	B	P		
PTM	Petroleum Naphtha	L	No	Yes	12	500/30 min		2	1	2	-	X	X	-	X	Yes [12]	Yes		
PHM	Phenol	S	No	Yes	18	5/19*		3	3	3	-	-	X	X	X	Yes	Yes		
PDL	Phenyldichloroarsine, Liquid	L	Yes	Yes	0.21	DNA		3	-	3	-	-	X	X	-	Yes	No		
PHI	Phenyldiazine Hydrochloride	S	No	No	< 0.25	DNA		3	3	2	-	-	X	X	-	Yes	No		
PHD	Phosdrin	L	No	Yes	-	0.01		(3)	(3)	(U)	-	-	X	X	X	-	Yes	Yes	As parathion [8]
PHG	Phosgene	G/L	Yes	No	> 760	0.1		3	-	3	-	-	X	X	-	Yes	Yes	Does not spontaneously ignite, stable in air	
PAC	Phosphoric Acid	L	No	No	< 0.25	0.23 [9]		2	-	2	-	-	X	X	-	Yes	Yes		
PPB	Phosphorous, Black	S	No	Yes	-	DNA					-	-	X	X	-	Yes	Yes		
PPD	Phosphorous Oxide	L	Yes	No	< 0.25	0.5		(3)	-	(3)	-	-	X	X	-	Yes	Yes	As hydrochloric acid [8]	
PPP	Phosphorous Pentasulfide	S	Yes	Yes	< 0.25	10 (H <sub>2</sub> S)		3	-	3	-	-	X	X	-	No	Yes	As hydrobromic acid [8]	
PBR	Phosphorous Tribromide	L	Yes	No	6.3	DNA		(3)	-	(3)	-	-	X	X	-	Yes	Yes	As hydrochloric acid [8]	
PPT	Phosphorous Trichloride	L	Yes	No	21	0.5		(3)	-	(3)	-	-	X	X	-	Yes	Yes		
PPR	Phosphorous, Red	S	Yes	Yes	< 0.25	DNA		(2)	-	(2)	-	-	X	Fire Suit	-	Yes	Yes	Reacts with water to form phosphine [5] which ignites. Waxy solid; Spontaneously ignites air @ 86°F	
PPW	Phosphorous, White	S	No	Yes	< 0.25	0.1* [9]		3	-	3	-	-	X	Fire Suit	-	Yes	Yes		
PAM	Phthalic Anhydride	S/L	Yes	Yes	< 0.01	1		1	-	1	-	-	X	-	-	Yes	Yes		
PPZ	Piperazine	S	No	Yes	2.9	DNA					-	-	X	-	-	Yes	Yes		
PLB	Polybutene	L	No	Yes	< 0.25	DNA		2	U	U	-	-	X	-	-	Yes	Yes	Vapor may act as asphyxiant [6]	
PCB	Polychlorinated Biphenyls	S/L	No	Yes	< 0.01	0.5		(3)	(3)	(2)	-	-	X	X	-	Yes	Yes	As olefins [8]	
PP1	Polyethylene Polyphenyl Isocyanate	L	-	Yes	0.0001	0.357* [9]					-	-	X	-	-	Yes	Yes	As chlorinated diphenyls [8]	
PPA	Polyphosphoric Acid	L	Yes	No	< 0.25	DNA		-	-	2	-	-	X	-	-	Yes	Yes	Polymer of methylene (4 phenyl)-isocyanate irritant [8]	
PLP	Polypropylene Glycol	S	No	Yes	< 0.25	DNA		U	U	U	-	-	-	-	-	Yes	Yes	Phosphorous comp. low toxicity	
PBG	Polypropylene Glycol	L	No	Yes	< 0.25	DNA					-	-	-	-	-	Yes	Yes	Nontoxic [5]	
PGM	Polypropylene Glycol Methyl Ether	L	No	Yes	< 0.25	DNA					-	-	-	-	-	Yes	Yes	Most indust. used glycols, not toxic [8]	
PTM	Potassium	S	Yes	Yes	< 0.25	DNA		3	-	3	-	-	X	Fire Suit	-	No (PVC)	Yes	Low toxicity; high conc. anesthetic. Caustic potash, mat'l. compat.	
PAS	Potassium Arsenate	S	No	No	< 0.25	0.5* [9]		3	-	2	-	-	X	-	-	Yes	Yes	Recognized carcinogen, As arsenic comp. [8]	
POA	Potassium Arsenite	S	No	-	-	DNA		3	-	2	-	-	X	-	-	Yes	Yes	As oxalates [8]	
PBO	Potassium Binoxalate	S	No	No	< 0.25	DNA		-	-	(3)	-	-	X	-	-	Yes	Yes		
PCR	Potassium Chlorate	S	No	Yes	< 0.25	DNA		-	-	1	X [10]	-	-	-	-	Yes	Yes		
PCH	Potassium Chromate	S	No	No	< 0.25	1* [9]		(3)	-	(3)	-	-	X	X	-	Yes	Yes	As chromium compounds [8]	
PTC	Potassium Cyanide	S	Yes	No	< 0.25	5* (CN) [5]		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	As cyanides [8]	
PDT	Potassium Dichloro-s-Triazinetrione	S	No	No	DNA	DNA		(3)	-	(3)	-	-	X	-	-	Yes	Yes	Irritates skin & eyes [9]	
PTD	Potassium Dichromate	S	No	No	< 0.25	DNA		(3)	-	(3)	-	-	X	-	-	Yes	Yes	Recognized carcinogen, As chromium compound [8]	
PTH	Potassium Hydroxide	S	Yes	No	< 0.25	DNA		3	-	3	-	-	X	X	-	Yes	No	Low toxicity [8]	
PTI	Potassium Iodide	S	No	No	< 0.25	DNA		2	-	-	-	-	X	-	-	Yes	Yes		
PTS	Potassium Oxalate	S	No	No	< 0.25	DNA		-	-	3	-	-	X	X	-	Yes	Yes		
PTP	Potassium Permanganate	S	No	No	< 0.25	DNA		3	-	3	-	-	X	X	-	Yes	Yes		
POP	Potassium Peroxide	S	Yes	Yes	< 0.25	DNA		(3)	-	(3)	-	-	X	X	-	Yes	Yes	As hydrogen peroxide, peroxides, inorganic [8]	
PBP	Propane	G	No	Yes	> 760	1000		1	0	0	-	-	X	-	-	Yes	Yes	Asphyxiant & CNS effect, high conc.	
PLT	Propylacetone, Beta	L	No	Yes	6.2	0.0 [9]		3	-	3	-	-	X	-	-	Yes	Yes	Experimental carcinogen [8]	
PAD	Propionaldehyde	L	No	Yes	51	DNA		2	-	2	-	-	X	-	-	Yes	No		

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAZ-TOXIC HAZARD RATING		LEVELS OF PROTECTION					MATERIAL COMPATI- BILITY(10)		NOTES	
						TWA	STEL	IN	SA	IR	PF	CC	AS	SS	MS	B		P
PNA	Propionic Acid	L	No	Yes	9.3	10	-	-	2	-	-	X(10)	-	-	X	Yes	Yes	Animal exp. indicate low toxicity;
PAH	Propionic Anhydride	L	No	Yes	3.6	DNA	-	-	(2)	-	-	-	-	-	X	Yes	Yes	As propionic acid [8]
PAT	n-Propyl Acetate	L	No	Yes	7	200	2	1	1	-	-	X	X	-	X	Yes	No(PVC [15] [11])	
PAL	n-Propyl Alcohol	L	No	Yes	37	260	2	2	1	-	-	X	X	-	X	Yes	Yes	Probably toxic[8], offensive smelling liquid
PMN	n-Propyl Mercaptan	L	No	Yes	276	DNA	U	U	U	-	-	-	X	X	-	Yes	Yes	
PRA	n-Propylamine	L	No	Yes	410	DNA	3	-	3	-	-	-	X	X	-	Yes	Yes	As olefins [6-8]
PPL	Propylene	G	No	Yes	> 760	4000	2	0	0	-	-	-	X	X	-	Yes	Yes	
PBP	Propylene Butylene Polymer	L	No	Yes	< 0.25	DNA	(2)	U	U	-	-	-	-	-	-	Yes	Yes	Montoxic [5]
PPG	Propylene Glycol	L	No	Yes	0.27	DNA	-	-	1	-	-	-	-	-	X	Yes	Yes	
PME	Propylene Glycol Methyl Ether	L	No	Yes	23	100	-	-	1	-	-	-	-	-	X	Yes	Yes	
PDX	Propylene Oxide	L	No	Yes	> 760	100	2	-	2	-	-	X	X	-	X	Yes	Yes	Irritant & narcotic in high conc. [9]
PTI	Propylene Tetramer	L	No	Yes	3.8	200 [9]	U	U	U	-	-	-	-	-	-	Yes	Yes	
PLI	Propyleneimine (Inhibited)	L	No	Yes	250	2	2	2	3	-	-	-	X	X	-	Yes	No	Experimental carcinogen [8]
PRR	Pyrethrins	L	No	-	DNA	DNA	3	-	2	-	-	-	-	-	-	Yes	No(ACE [12])	Household insecticide [5]
PRD	Pyridine	L	No	Yes	41	5	1	2	2	-	-	X	-	-	-	Yes	Yes	
PGA	Pyrogalllic Acid	S	No	Yes	< 0.25	DNA	3	3	3	-	-	-	X	X	-	Yes	Yes	May produce retinitis [8]. Irritates eyes & skin [9]
QNL	Quinoline	L	No	Yes[5]	0.3	DNA	3	U	U	-	-	-	X	-	-			As selenium compounds [8]
RSC	Resorcinol	S	No	Yes	0.0087	10	2	2	2	-	-	X	X	-	X	Yes	Yes	
SLA	Salicylic Acid	S	No	Yes	< 0.25	DNA	-	-	2	-	-	-	-	-	-	Yes	Yes	As selenium compounds [8]
SLD	Selenium Dioxide	S	No	Yes	< 0.25	0.2*(Se) [9]	(2-3)	-	(2)	-	-	-	-	-	-	Yes	Yes	Irritates skin & eyes, harmful if swallowed [9]
STO	Selenium Trioxide	S	No	No	< 0.25	0.2*(Se) [9]	(2-3)	-	(2)	-	-	-	X	X	-	Yes	Yes	As selenium compounds [8]
STC	Silicone Tetrachloride	L	Yes	No	383	DNA	3	-	3	-	-	-	-	-	-	Yes	Yes	Irritates skin & eyes, harmful if swallowed [9]
SVA	Silver Acetate	S	No	No	< 0.25	0.01*(Ag) [9]					X	-	-	-	-	Yes	Yes	Irritates skin & eyes [9]
SVC	Silver Carbonate	S	No	No	< 0.25	"					X	-	-	-	-	Yes	Yes	As fluorides [8]
SVF	Silver Fluoride	S	No	No	< 0.25	"	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	Similar to bromates & chlorates As chlorates[8], irr. skin & eyes[9]
SVI	Silver Iodate	S	No	Yes	< 0.25	"	-	-	1	-	-	-	-	-	-	Yes	Yes	As nitrates[8], irr. skin & eyes[9]
SVN	Silver Nitrate	S	No	No	< 0.25	DNA	(3)	U	U	-	-	-	X	-	-	Yes	Yes	As silver compounds [8]
SVO	Silver Oxide	S	No	No	< 0.25	0.01*(Ag)	-	-	-	-	-	-	-	-	-	Yes	Yes	As silver compounds[8], irritates skin & eyes [9]
SVS	Silver Sulfate	S	No	No	< 0.25	"	-	-	-	-	X	-	-	-	-	Yes	Yes	Irr. to skin & eyes [9]
SAS	Silver Alkyl Sulfates	S	No	-	< 0.25	DNA				-	-	X	-	-	-	Yes	Yes	As NaOH&NH3-reaction w/H2O [8]
SAB	Sodium Alkylbenzene Sulfonates	S/L	No	No	< 0.25	DNA	(3)	-	(3)	-	-	-	X	X	-	Yes	Yes	
SAM	Sodium Amide	S	Yes	Yes	< 0.25	DNA					-	-	-	-	-	Yes	Yes	As arsenic compounds, recognized carcinogen [8]
SDA	Sodium Arsenate	S	No	No	< 0.25	0.5*(As)	(2)	-	(3)	-	-	-	X	X	-	Yes	Yes	As arsenic compd, herbicide[8]
SAR	Sodium Arsenite	S	No	No	< 0.25	"	(2)	-	(3)	-	-	-	X	X	-	Yes	Yes	As sodium hydroxide [8]
S/Z	Sodium Azide	S	No	Yes	DNA	0.1(0.3*)	(2)	-	(3)	-	-	-	X	X	-	Yes	Yes	As fluorides [3]
SBF	Sodium Bifluoride	S	No	No	-	2.5*(F)[5]	(3)	-	(3)	-	-	-	-	-	-	Yes	Yes	
SBS	Sodium Bisulfite	S	No	No	< 0.25	DNA	(2)	-	-	-	X	X	-	-	-	Yes[11]	(PVC) [11]	As sulfites [8]
SDB	Sodium Borate	S	No	No	< 0.25	DNA	(2)	U	U	U	X	X	-	-	-	Yes	Yes	As boron compounds [8]
SBH	Sodium Borohydride	S	Yes	Yes	< 0.25	2*(NaOH) [5]	(2)	U	U	U	X	X	-	-	-	Yes	Yes	As boron compound with moisture [8], NaOH may be present
SCD	Sodium Cacodylate	S	No	No	< 0.25	DNA	(1)	-	1	1	X	-	-	-	-	Yes	Yes	As cacodylic acid [8]

C	CN	S	WR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAZ-TOXIC HAZARD RATING	LEVELS OF PROTECTION					MATERIAL CORROSIVE-BILI... [10]		NOTES		
						TWA	STEL		RESPIRATORY					CLOTHING			B	P
									PF	CC	AS	SS	NS					
SDC	Sodium Chlorate	S	No	No	<0.25	DNA		2	X	X	-	-	X	Yes	Yes	As chromium compd., carcinogen [8]		
SDH	Sodium Chromate	S	No	No	<0.25	0.1*		(3)	-	-	X	X	-	Yes	Yes	As cyanides [8]		
SDI	Sodium Cyanide	S	Yes	No	<0.25	5*(CN)[5]		(3)	-	-	X	X	-	Yes [11]	Yes [12]	As cyanides [8]		
SDT	Sodium Dichloro-s-Triazinetrione	S	No	No	<0.25	DNA			X	-	-	-	X	Yes	Yes	Irritates skin & eyes [9]		
SCR	Sodium Dichromate	S	No	No	<0.25	DNA		(3)	-	-	X	X	-	Yes	Yes	As chromium compounds, carcinogen [8]		
SFC	Sodium Ferrocyanide	S	No	No	<0.25	DNA		-	X [6]	-	-	-	X	Yes	Yes	As ferrocyanides [8] avoid acid contact		
SDF	Sodium Fluoride	S	No	No	<0.25	DNA		(3)	-	-	X	X	-	Yes	Yes	As fluorides [8]		
SDH	Sodium Hydride	S	Yes	Yes	DNA	DNA		(2)	-	-	X	X	-	Yes	Yes	As sodium hydroxide [8]		
SHS	Sodium Hydrosulfide Solution	L	No	No	<0.25	DNA			-	-	X	X	-	Yes	Yes	As sulfides (skin irritant) irritates skin & eyes [9]		
SHD	Sodium Hydroxide	S	Yes	No	<0.25	2*/[5] min		2	-	-	X	X	-	Yes	Yes	As sodium hydroxide [8]		
SHC	Sodium Hypochlorite	L	Yes	No	<0.25	DNA		U	-	-	X	X	-	Yes	Yes	As hypochlorites [8]		
SHL	Sodium Methylate	S	Yes	Yes	<0.25	200 (CH <sub>3</sub> OH)		(2)	X	-	-	-	X	Yes [11]	Yes [12]	Toxic & corr. to tissues [5]		
SDN	Sodium Nitrate	S	No	Yes	<0.25	DNA			-	-	-	-	-	Yes	Yes	Toxic rating as nitrates		
SNT	Sodium Nitrite	S	No	Yes	<0.25	DNA		(3)	-	-	X	X	-	Yes	Yes	Toxic rating as nitrate, irritates skin & eyes [9]		
SOX	Sodium Oxalate	S	No	No	<0.25	DNA		-	-	-	X	X	-	Yes	Yes	Toxic rating as oxalates		
SPP	Sodium Phosphate	S	No	No	<0.25	DNA			X	-	-	-	-	Yes [11]	Yes [12]	Mild irritant; skin & eyes [9]		
SSE	Sodium Selenite	S	No	No		0.2*(Se) [5]		(2-3)	-	-	X	X	-			Toxic rating as selenium, recognized carcinogen		
SSC	Sodium Silicate	L	No	No	<0.25	DNA		(3)	-	-	-	-	-	Yes	Yes	Nontoxic [5]		
SER	Sodium Silicofluoride	S	No	Yes	<0.25	2.5* DNA			-	-	X	X	-	Yes	Yes	Toxic rating as fluosilicates		
SUS	Sodium Sulfide	S	No	No	<0.25	DNA			-	-	X	X	-	Yes	Yes	Strong irrit. to skin & tissue [5], unstable H <sub>2</sub> S produced		
SSF	Sodium Sulfite	S	No	No	<0.25	DNA		(2)	X	X	-	-	X	Yes	Yes	Toxic rating as sulfites		
SCY	Sodium Thiocyanate	S	No	No	<0.25	DNA			X	-	-	-	X	Yes	Yes	Low toxicity [8], toxic by ingestion, irrit. skin, eyes, nose, throat [9]		
SDU	Sodium, Metallic	S	Yes	Yes	<0.25	DNA		3	-	-	X	Fire	Suit	No	Yes	Reacts with moisture, burns [9]		
SBT	Sorbitol	S	No	No	<0.25	DNA			X	-	-	-	-	Yes	Yes	Little toxicity [8]		
STF	Stannous Fluoride	S	No	-	2*(Sn) [5]	DNA		(3)	-	-	X	X	-	Yes	Yes	As fluorides [8]		
SRA	Stearic Acid	S	No	-	<0.25	0.5*(Cr)		(3)	X	-	-	X	-	Yes	Yes	Slight toxicity [8], nontoxic [5]		
SCM	Strontium Chromate	S	No	-	DNA	0.15*			-	-	X	X	-	Yes	Yes	As chromium compounds [3]		
STR	Strychnine	S	No	-	DNA	0.15*			-	-	X	X	-	Yes	Yes	Toxic by inhalation & ingestion [5], extremely toxic		
STY	Styrene	L	Yes	Yes	13	100		2	-	X	X	-	X	No	Yes	Nontoxic nuisance dust [8]		
SRS	Sucrose	S	No	Yes	<0.25	DNA			X	-	-	-	-	Yes	Yes	Solvent		
SFL	Sulfonate	L	No	Yes	<0.25	DNA		(3)	-	-	X	X	-	Yes	Yes	Can accumulate H <sub>2</sub> S. Toxic rating as H <sub>2</sub> S		
SXX	Sulfur (Liquid) @ 113 to 120°C	L	No	Yes	<0.10	10 (H <sub>2</sub> S)			-	-	-	-	-	Yes	Yes			
SFD	Sulfur Dioxide	G/L	Yes	No	>760	5		3	-	-	X	X	-	Yes	Yes			
SFM	Sulfur Monochloride	L	Yes	Yes	>22	1		3	-	-	X	X	-	Yes	Yes			
SFA	Sulfuric Acid	L	Yes	No	<0.25	1*		3	-	-	X	X	-	No	Yes	75% H <sub>2</sub> SO <sub>4</sub> - butyl OK @ 100F		
SAC	Sulfuric Acid, Spent	L	Yes	No	<0.25	DNA		3	-	-	X	X	-	Yes	Yes			
SCL	Sulfonyl Chloride	L	Yes	No	>5	5 (HCl) [8]		(3)	-	-	X	X	-	Yes	Yes	As HCl or H <sub>2</sub> SO <sub>4</sub> [8]		
TES	2,4,5-T Esters	S	No	No	<0.25	10*			-	-	X	X	-	Yes	Yes	Highly toxic selective herbicide		
TLO	Tallow	L	No	Yes	<0.25	DNA			-	-	-	-	-	Yes	Yes	Nontoxic [5], not harmful [9]		
TFA	Tallow Fatty Alcohol	S	No	Yes	<0.25	DNA			-	-	-	-	-	Yes	Yes	Nontoxic [10], not harmful [9]		

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAZ-TOXIC HAZARD RATING		LEVELS OF PROTECTION					MATERIAL COMPATI- BILITY [10]		NOTES	
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY CLOTHING			NS	B		P
												CC	AS	SS				
TMA	Tannic Acid	S	No	Yes	<0.25	DNA		2	-	1	X	X	-	-	X	Yes	Yes	As titanium compd[8].toxic, irritates skin & eyes[9]
TBT	Tetrabutyl Titanate	L	Yes	Yes	<0.25	DNA		(1)	-	-	-	X	-	-	X	Yes	Yes	
TEC	Tetrachloroethane	L	Yes	No	18	5	10	3	3	2	-	-	X	X	-	No	No	
TTE	Tetrachloroethylene	L	No	No	37.2	100	150	2	2	2	-	-	X	X	-	Yes	No	
TTM	Tetradecanol	L	No	Yes	<0.25	DNA		U	U	U	-	X	-	-	X	Yes	Yes	Irritates skin & eyes [9] Probably irritant & narcotic in high conc:eye irrit. [9] Irritates skin & eyes [9] As parathion cholinesterase inhib.
TTD	1-Tetradecene	L	No	Yes	<0.25	DNA		U	U	U	-	X	-	-	X	Yes	Yes	
TDB	Tetradecylbenzene	L	-	Yes	<0.25	DNA		(3)	(3)	-	-	X	-	-	X	Yes	Yes	
TED	Tetraethyl Dithiopyrophosphate	S	No	No	<0.25	0.2*	0.6*	(3)	(3)	-	-	-	X	X	-	Yes	Yes	
TEL	Tetraethyl Lead	L	No	Yes	82.7	0.007		3	-	-	-	-	X	X	-	No, Yes	No	Intoxication via skin absorption [8] Low toxicity[5], no respira- tory required[10] & skin[5] Asphyxiant, may be toxic[8] Irritates skin & eyes [9] Like tetraethyl lead [8] skin absorption occurs As phosgene [8] Recognized carcinogen[8]. Low chemical toxicity
TEP	Tetraethyl Pyrophosphate	L	No	No	<0.25	0.0039		3	3	-	-	-	X	X	-	Yes	Yes	
TTG	Tetraethylene Glycol	L	No	Yes	<0.25	DNA					-	-	-	-	-	Yes	Yes	
TTP	Tetraethylenepentamine	L	No	Yes	<0.01	DNA					-	-	X	X	-	Yes	Yes	
TFE	Tetrafluoroethylene (inhibited)	G	No	Yes	>760	DNA					-	-	-	-	-	Yes	Yes	
THF	Tetrahydrofuran	L	No	Yes	263	200	250	3	-	3	-	-	X	X	-	Yes	No	
THM	Tetrahydronaphthalene	L	No	Yes	1.3	25		2	-	2	-	-	X	X	-	Yes	No	
TML	Tetramethyl Lead	L	No	Yes	75	0.009		3	-	-	-	-	X	X	-	No	Yes	
TPG	Thiophosgene	L	Yes	Yes	160	0.1		(3)	-	(3)	-	-	X	X	-	Yes	Yes	
THR	Thiram	S	No	No	<0.25	5*		2	-	1	X	-	-	-	-	Yes	Yes	
TRN	Thorium Nitrate	S	No	Yes	<0.25	DNA					-	-	-	-	-	Yes	Yes	
TTT	Titanium Tetrachloride	L	Yes	No	5	5		3	-	3	-	-	X	X	-	No	No	
TOL	Toluene	L	No	Yes	51.7	100	150	2	1	1	-	X	X	-	X	No	No	Toxicity as o-toluene- sulfonic acid Toxic rating as parathion, highly toxic [5] Causes cancer in mice,car- cinogen Toxic rating as fluotri- chloromethane as chlor-pheno- toxic selective herbicide[8] Animal expmts. indicate low toxicity [8], eye irritant [9] Low toxicity [5] Ignites spontaneously in air, highly toxic & irritant Animal expmts. indicate high toxicity [8]
TDI	Toluene 2,4-Diisocyanate	L	Yes	Yes	0.07	0.02		3	-	3	-	-	X	X	-	Yes	Yes	
TAP	p-Toluene Sulfonic Acid	S	No	Yes	<0.25	DNA		(3)	-	(3)	-	-	X	X	-	Yes	Yes	
ILI	o-Toluidine	L	No	Yes	8	5	10	3	1	2	-	-	X	X	-	No	No	
TXP	Toxaphene	S	No	No	<0.25	0.5*		3	3	2	-	-	X	X	-	Yes	Yes	
TRC	Trichlorfon	S	No	-		DNA		(3)	(3)	2	-	-	X	X	-	Yes	Yes	
TCT	Trichloro-s-Triazinetrione	S	No	No	<0.1	DNA		-	-	2	X[9]	X[9]	-	-	-	Yes	Yes	
TCE	Trichloroethane	L	Yes	Yes	212	350	440	2	2	1	-	-	X	X	-	Yes	No	
TCL	Trichloroethylene	L	No	No	129	100	150	3	-	1	-	-	X	X	-	No	No	Toxicity as o-toluene- sulfonic acid Toxic rating as parathion, highly toxic [5] Causes cancer in mice,car- cinogen Toxic rating as fluotri- chloromethane as chlor-pheno- toxic selective herbicide[8] Animal expmts. indicate low toxicity [8], eye irritant [9] Low toxicity [5] Ignites spontaneously in air, highly toxic & irritant Animal expmts. indicate high toxicity [8]
TCF	Trichlorofluoromethane	L	No	No	1190	1000		(2)	(1)	(1)	-	-	X	X	-	No	No	
TPH	Trichlorophenol	S	No	No	<0.25	DNA		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	
ICA	2,4,5-Trichlorophenoxy Acetic Acid	S	No	Yes	<0.01	DNA		(3)	(3)	(3)	-	-	X	X	-	Yes	Yes	
TCS	Trichlorostilbene	L	Yes	Yes	<760	(5)(HCl)		2	-	2	-	-	X	X	-	Yes	No	
TCP	Tricresyl Phosphate	L	No	Yes	<0.25	0.1*(2)		2	2	2	-	-	X	X	-	Yes	No	
TOK	Tridecanol	L	No	Yes	<0.25	DNA		U	U	U	-	-	X	X	-	Yes	Yes	
TDC	1-Tridecene	L	No	Yes	0.14	DNA					-	-	-	-	-	No	No	
TEA	Triethanolamine	L	No	Yes	<0.1	DNA		-	1	1	-	-	X	-	-	Yes	No	Toxicity as o-toluene- sulfonic acid Toxic rating as parathion, highly toxic [5] Causes cancer in mice,car- cinogen Toxic rating as fluotri- chloromethane as chlor-pheno- toxic selective herbicide[8] Animal expmts. indicate low toxicity [8], eye irritant [9] Low toxicity [5] Ignites spontaneously in air, highly toxic & irritant Animal expmts. indicate high toxicity [8]
TAL	Triethylaluminum	L	Yes	Yes	<0.11	DNA					-	-	X	Fire Suit	-	Yes	No	
TEN	Triethylamine	L	No	Yes	119	25	40	3	-	3	-	-	X	X	-	Yes	No	
TEB	Triethylbenzene	L	No	Yes	1.5	DNA		U	U	U	-	-	X	X	-	Yes	Yes	

C	CN	S	WR	F	VP	TLV (ppm OR mg/m <sup>3</sup> )*		SAX-TOXIC HAZARD RATING			LEVELS OF PROTECTION CLOTHING					MATERIAL COMPATIBILITY [10]		NOTES
						THA	STEL	IN	SA	IR	PF	CC	AS	SS	MS	B	P	
TEG	Triethylene Glycol	L	No	Yes	<0.25	DNA		3	-		-	X	-	-	-	Yes	Yes	Low toxicity [5]
TET	Triethylenetetramine	L	No	Yes	<0.25	DNA				3	-	-	-	X	-	Yes	No	Strong irritant to tissue, causes skin burns [5]
TFC	Trifluorochloroethylene	G	Yes	Yes	<760	20		1	U	U	-	-	-	-	-			An asphyxiant, moderately toxic [5]
TFR	Trifluorolene	S	No	Yes	<0.25	DNA		U	U	U	X	-	-	-	-			Animal experts indicate low toxicity [8]
TIA	Triisobutylamine	L	Yes	Yes	0.4	DNA					-	-	-	-	-	Yes	Yes	Ignites spontaneously in air [5]
TMA	Triethylamine	G	Yes	Yes	>760	(5) (HCl)		2	-		-	-	-	-	-	Yes	Yes	Toxic, destructive living tissue [5]
TMC	Trimethylchlorosilane	L	Yes	Yes	375	(5) (HCl)		(3)	-		-	-	-	-	-			Toxic by inhal. burns skin [5]
TGC	Tripropylene Glycol	L	No	Yes	<0.25	DNA					-	-	-	-	-			Toxic rating as silanes. Strong irritant to tissues [5]
TPO	Tris(Aziridinyl) Phosphine Oxide	S	-	-	DNA	DNA					-	-	-	-	-			Low toxicity [5], not harmful
TPT	Turpentine	L	No	Yes	14	100		2	2	2	-	-	-	-	-	Yes	Yes	Irritating skin & eyes; protect skin [9], highly toxic [8]
UND	Undecano. (1-)	L	No	Yes	<0.25	DNA					-	-	-	-	-	Yes	Yes	Low toxicity [5], eye irrit. [9]
UDC	1-Undecene	L	No	Yes	1.2	DNA					-	-	-	-	-	Yes	Yes	Irritating skin & eyes [9]
UBB	n-Undecylbenzene	L	-	Yes	<0.25	DNA					-	-	-	-	-			Recognized carcinogen, as uranium highly acute toxicity [8]
UBP	Uranium Peroxide	S	-	Yes	<0.25	0.2*	0.6*				-	-	-	-	-	Yes	Yes	Highly toxic [5]
URA	Uranyl Acetate	S	No	Yes	<0.25	3*					-	-	-	-	-	Yes	Yes	See uranium oxysulfide
URN	Uranyl Nitrate	S	No	Yes	<0.25	15*					-	-	-	-	-	Yes	Yes	Essentially nontoxic [8], not harmful [9]
URS	Uranyl Sulfate	S	No	Yes	<0.25	0.2*(U)					-	-	-	-	-	Yes	Yes	Decomposed by moisture at temp. above 40°C [5]
URE	Urea	S	No	No	DNA	DNA				2	X	-	-	-	-	Yes	Yes	Low toxicity
UPD	Urea Peroxide	S	No	Yes	DNA	DNA		-		1	-	-	-	-	-	Yes	No	Hydrolyzes [5,8], toxic rating as H <sub>2</sub> O <sub>2</sub>
VAL	Valeraldehyde	L	No	Yes	69	50		2	-	(3)	-	-	-	-	-	Yes	No	Toxic rating as vanadium, toxic by inhalation, variable toxicity
VOT	Vanadium Oxidichloride	L	Yes	No	<40	5 (HCl)		(3)	-	(3)	-	-	-	-	-	Yes	Yes	May be toxic & irritant [5]
VOX	Vanadium Pentoxide	S	No	No	<0.25	DNA					-	-	-	-	-	Yes	Yes	Carcinogen; no allowable exposure
VSF	Vanadyl Sulfate	S	No	No	<0.25	DNA		1	-	1	-	-	-	-	-	Yes	Yes	Toxic rating ethers; acute effects high conc. [8]
VAM	Vinyl Acetate	L	No	Yes	<0.25	207		2	U	U	-	-	-	-	-	Yes	Yes	Toxic rating as fluorides
VCH	Vinyl Chloride	L/G	No	Yes	>760	0		2	U	U	-	-	-	-	-	Yes	Yes	Irritates eyes, nose, throat, liquid causes frostbite [9]
VEE	Vinyl Ethyl Ether	L/G	No	Yes	>760	DNA		2	U	U	-	-	-	-	-	Yes	Yes	Toxic rating as vinyl chloride [8], burns skin [9]
VFI	Vinyl Fluoride (Inhibited)	G	No	Yes	>760	2.5*(F)		(3)	-	U	-	-	-	-	-			Mod. toxic [5], chronic exp. damages kidneys & liver [8,9]
VME	Vinyl Methyl Ether (Inhibited)	L/G	No	Yes	>760	DNA		U	U	U	-	-	-	-	-	Yes	Yes	Fuming liquid
VCI	Vinylidenechloride (Inhibited)	L	No	Yes	>760	10		(2)	-	(2)	-	-	-	-	-	Yes	No	Toxic rating as vinyl chloride [8], burns skin [9]
VMT	Vinyl Toluene	L	No	Yes	3.5	100					-	-	-	-	-	No	No	Mod. toxic [5], chronic exp. damages kidneys & liver [8,9]
VTS	Vinyl Trichlorosilane	L	Yes	Yes	146	5 (HCl)		3	-	3	-	-	-	-	-	Yes	No	Fuming liquid
WCA	Wax: Carnuba	L	No	Yes	<0.25	DNA		0	0	0	-	-	-	-	-	Yes	Yes	Flames, carcinogen of stomach
WPF	Wax: Paraffin	S/L	No	Yes	<0.25	2*		0	0	0	-	-	-	-	-	Yes	Yes	
XLN	Xylene (M-)	L	No	Yes	17	100		2	2	1	-	-	-	-	-	No (PVC)	No [12]	
XLO	Xylene (O-)	L	No	Yes	14	100		2	2	1	-	-	-	-	-	"	"	
XLN	Xylene (P-)	L	No	Yes	18	100		2	2	1	-	-	-	-	-	"	"	
XYL	Xylenol	S	No	Yes	0.47	45		(3)	(3)	(3)	-	-	-	-	-	Yes	Yes	Toxic rating as phenol
ZEC	Zectran	S	No	No	<<0.1	DNA					-	-	-	-	-			Insecticide
ZMA	Zinc Acetate	S	No	No	<0.25	DNA					X	-	-	-	-	Yes	Yes	Toxic rating as Zn compd. Low toxicity [8], irrit. eyes, nose, eye
ZAC	Zinc Ammonium Chloride	S	No	No	<0.25	DNA					-	-	-	-	-			Irrit. skin, eyes, nose, throat [9]

C	CN	S	MR	F	VP	TLV (PPM OR MG/M <sup>3</sup> )*		SAV-TOXIC HAZARD RATING			LEVELS OF PROTECTION RESPIRATORY CLOTHINGS					MATERIAL COMPATI- BILITY [10]			NOTES
						TWA	STEL	IN	SA	IR	PF	RESPIRATORY			SS	NS	B	P	
												CC	AS	SS					
ZAR	Zinc Arsenate	S	No	No	<0.25	0.013		(3)	-	(2)	-	-	X	X	-	-	Yes	Yes	Carcinogen [8], toxic rating as arsenic
ZBC	Zinc Bichromate	S	No	No	<0.25	0.1*		(3)	-	(3)	-	-	X	X	-	-	Yes	Yes	Carcinogen, toxic rating as Cr and toxic rating as boron compds;
ZBO	Zinc Borate	S	No	No	<0.25	10*		(2)	U	U	-	-	-	-	-	-	Yes	Yes	Low toxicity [5], toxic rating as low toxicity [5]
ZBR	Zinc Bromide	S	No	No	<0.25	DNA		(2)	-	(1)	X	X	-	-	-	-	Yes	Yes	Non-toxic [5], traces added to animal feeds
ZCB	Zinc Carbonate	S	No	No	<0.25	DNA					X	-	-	-	-	-	Yes	Yes	Fumes highly toxic. Soln. irrit.
ZCL	Zinc Chloride	S	No	No	<0.25	1*		(3)	-	(3)	-	-	X	X	-	-	Yes	Yes	Carcinogen, toxic rating as Cr and toxic by inhalation [5].
ZCR	Zinc Chromate	S	No	No	<0.25	0.05*		(3)	-	(1)	-	-	X	X	-	-	Yes	Yes	Toxic by inhalation [5], toxic rating as low toxicity [5]
ZCN	Zinc Cyanide	S	No	No	<0.25	DNA		(3)	(3)	(1)	-	-	X	X	-	-			Lube oil additive [5], skin & tissue irritant [9].
ZDP	Zinc Dialkylidithiophosphate	L	No	Yes	<0.25	DNA					-	-	-	-	-	-			Toxic rating as fluorides [8]
ZFB	Zinc Fluoborate	L	No	No	<0.25	DNA		(3)	-	(3)	-	-	X	X	-	-			May be toxic by ingestion [5]
ZFX	Zinc Fluoride	S	No	No	<0.25	2.5* (F)		(3)	-	(2)	-	-	X	X	-	-			Toxic rating as formic acid
ZFM	Zinc Formate	S	No	-	<0.25	DNA		(2)	U	U	X	-	-	-	-	-			Zinc compounds low toxicity.
ZHS	Zinc Hydrosulfite	S	No	-	DNA	DNA		(2)	U	U	X	-	-	-	-	-			Mod. toxic [5], toxic rating as nitrate
ZMT	Zinc Nitrate	S	No	No	<0.25	DNA		(2)	-	-	X	X	-	-	-	-	Yes	Yes	Toxic by ingest. [5], eye, skin irrit.
ZPS	Zinc Phenolsulfonate	S	No	No	<0.25	DNA		(3)	-	(2)	-	-	X	X	-	-	Yes	Yes	Toxic by ingest. as phosphine
ZPB	Zinc Phosphide	S	No	No	<0.25	DNA		(3)	-	(2)	-	-	-	-	-	-	Yes	Yes	Toxic by ingest. ZINC CHROMATE is carcinogen
ZPL	Zinc Potassium Chromate	S	No	-	DNA	DNA		(3)	-	(3)	-	-	X	X	-	-	Yes	Yes	Toxic rating as fluosulfates
ZSL	Zinc Silicofluoride	S	No	No	DNA	2.5% DNA		(3)	-	(3)	-	-	X	X	-	-	Yes	Yes	Low toxicity [5], skin tissue irrit.
ZSF	Zinc Sulfate	S	No	No	<0.25	5* (Zr)					X	-	-	-	-	-	Yes	No	Toxic by inhalation [5], skin, tissue irritant [9]
ZCA	Zinc Acetate	S	No	No	<0.25	5* (Zr)					X	-	-	-	-	-	Yes	Yes	Toxic rating as nitrates, skin, tissue irritant [9]
ZIR	Zirconium Nitrate	S	No	No	<0.25	5* (Zr)		(2)			X	-	-	-	-	-	Yes	Yes	No toxic data [5,8]
ZCO	Zirconium Oxichloride	S	No	No	DNA	5* (Zr)		(3)	-	(3)	-	-	X	X	-	-	Yes	Yes	Toxic & irritant [5], toxic rating as fluorides [9]
ZPF	Zirconium Potassium Fluoride	S	No	-	DNA	2.5* [5] (F)					X	-	-	-	-	-	Yes	Yes	Toxic rating as HCl acid,
ZCS	Zirconium Sulfate	S	No	No	<0.25	5* (Zr)		(3)	-	(3)	-	-	X	X	-	-	Yes	Yes	toxic & irritant [5]
ZCT	Zirconium Tetrachloride	S	Yes	-	DNA	5* [5] (Zr)		(3)	-	(3)	-	-	X	X	-	-			

APPENDIX B

MANUFACTURERS AND SUPPLIERS OF PROTECTIVE EQUIPMENT

B-1

PROTECTIVE CLOTHING  
HOODS/GOGGLES/FACESHIELDS

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
Hood #460-625 (Air Supplied)	Fabohio, Inc.	Vinyl
Hood #420-620	" "	Vinyl
Helmet (Acid Helmet) 15836	Wheeler Protective Apparel, Inc.	Fiberglass with Vinyl window
Hood Three Piece Style F-100-80	Norton Safety Products Div.	Neoprene/Nylon
Hood, Three Piece Style 98-300	" " "	Polyurethane/Nylon
Hood, Two Piece Style NSVP-80	" " "	Vinyl/Nylon
Hood, Three Piece Style 58-00	" " "	Vinyl/Nylon 14-15 oz
Goggle, Flexible Frame Style 1022 (Chemical Splash-High Humidity)	" " "	--
Faceshield, Model 7-10	" " "	Acetate
Chemgard Acid Hood (Air Line Supply Type) Cat. No. 79168	Mine Safety Appliances Co.	Vinyl/Cotton
Chemgard Acid Hood Cat. No. 38022	" " "	Vinyl/Cotton
A-1-A Firefighter Hood Cat. No. 75514	" " "	Glass Fiber
Skullgard Faceshield Frame	" " "	Cellulose Acetate
Chemical Splash Goggle Cat. No. 791079, clear Cat. No. 791082, yellow	Mine Safety Appliances Co.	Polycarbonate Polycarbonate
Wide Vision Goggle Cat. No. 791081	" "	Polycarbonate
Rubber Frame Goggle Cat. No. 791072, clear Cat. No. 791072, with breathing vent	" "	Polycarbonate Polycarbonate

Goggles, Encon 160 EN Fog Lens-0.06" Poly- carbonate, Pt. No. 01-4000-51	Encon Manufacturing Co. " " "	Vinyl Vinyl/Neoprene Strap
Regular Lens-0.06" Polycarbonate, Pt. No. 01-400-55	" " "	Vinyl/Neoprene Strap
Hood, Air Supplied Series 6000	Rich Industries	Vinyl
Acid Hood	Rich Industries	Vinyl
Splashproof Hood #H-516(Cape Style)	Jomac Products, Inc.	Vinyl/Fiberglass
Hood, SD-3672 Series	Standard Safety Equipment Co.	Gralite
Hood, Self Ventilating SD-3884	" " "	Gralite
Hood, Shoulder Mounted SD-5424	" " "	Gralite
Mounted Hood SD-4196	" " "	Gralite
Hood, SD-3943 (for Scottoramic Face Mask)	" " "	Gralite
Acid Hood with Hard Cap, SD-4435, SD-4432, SD-4107	" " "	Gralite
Airborne Dust Hood SD-3478, SD-5308	" " "	Gralite
Hood, Shoulder Length #186-11	Encon Manufacturing Co.	Neoprene/Nomex
Style Hood #5361-11	" " "	Neoprene/Nomex
Style Hood/Safety Cap #6410-11	" " "	Neoprene/Nomex

PROTECTIVE CLOTHING  
BOOTS/SHOE COVERS

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
"TV" (TRI-VAC) 2TV04010(16") Steel Toe	Boss Manufacturing Company	Natural Rubber Neoprene or Vinyl
Rubber Knee 2TV-4010(16") Steel Toe	Boss Manufacturing Co.	" "
Industrial Rubber Hip 2HS-6231 Steel Toe	Boss Manufacturing Company	Black Rubber
Boots 320-840	Fabchio, Inc.	Vinyl
Overshoe 68974	Wheeler Protective Apparel Inc.	Vinyl
Leggings/Spats Leggings, Style 57-00 (Hip Length) Spats, Style 57-01	Norton Safety Products Div.	Neoprene/Cotton  Neoprene/Cotton
Shoe Cover, Booties Series 1000	Rich Industries	Vinyl
Leggings, Hip Length Cat.No. 37690(29") Cat.No. 37691(30") Cat.No. 37692(31")	Mine Safety Appliances Co.	Neoprene Latex/Cotton
Spats, #37689	Mine Safety Appliances Co.	Neoprene Latex/Cotton
Seal-Tight Boots (with steel toe, for use with Standard Safety complete en- closure garments)	Standard Safety Equipment Co.	Neoprene
Gralite Boots SD-3528	" " "	Gralite
Gralite Waders SD-4139	" " "	Gralite-20

PROTECTIVE CLOTHING  
Gloves/Gauntlets/Sleeves

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
Tyvek Sleeve No.08-004518 (Throw-Away)	Singer Safety Products	Tyvek (Polyethylene)
Disposable Poly- ethylene Glove 36-001151 (small) 36-001152 (medium) 36-001153 (large)	" " "	Tyvek (Polyethylene)
Black Stanzoils IUN-0054 (.030 gage) 14 in. long	Boss Manufacturing Co.	Neoprene Coated
Heavy Weight Safety Cuff ISP-5115	" " "	Vinyl Coated
Tough Wear IUH-0343 (.024 gage) 12 3/4 in. long	" " "	Nitrile Rubber
Interlocking Glove/ Ring Assembly, Acidwear 150000 (Sleevelets, rings, gloves)	Wheeler Protective Apparel, Inc.	Vinyl
Sleeves, 55-00	Norton Safety Products Div.	Neoprene/cotton
Glove, Super Flexible Knitwrist Cat.No. 37642 12" Gauntlet Cat.No. 37643	Mine Safety Appliances Co.	Vinyl/Jersey Lining
Glove, Python Knitwrist Cat.No. 37993 Gauntlet (14") Cat.No. 37994	" " "	Neoprene/Canton Flannel Lining
Glove, Butyl Rubber, 14" Cat.No. 38554 (size 9) Cat.No. 38555 (size 10) Cat.No. 38556 (size 11)	" " "	Butyl

Redmont Gauntlet  
(Heavy Duty Line)

Edmont-Wilson Div. Bechton,  
Dickinson & Co.

Neoprene

Grappler, 14" Gauntlet  
Premium PVC Line  
#05619

" " "

Vinyl Coated

PVA, 14" Gauntlet  
Fully Coated,  
#14306

" " "

Polyvinyl Coated  
Alcohol

Coated Gloves, PVC  
Heavy Duty  
#9112, 12" Gauntlet  
#9114, 14" Gauntlet  
#9116, 16" Gauntlet  
#9118, 18" Gauntlet

Jomac Products, Inc.

Vinyl

Gloves, SD4313,  
SD5525

Standard Safety Equipment Co.

Graylite

# PROTECTIVE CLOTHING

## JACKETS/SHOP COATS

<u>Name</u>	<u>Manufacturer</u>	<u>Material</u>
TYVEK 40" Shop Coat (Disposable) No-08-004701-Small through No.08-004704-XLarge (Knee Length)	Singer Safety Products	Tyvek (Polyethylene)
Coat, Acidwear 30036	Wheeler Protective Apparel, Inc.	Vinyl
Jacket Style F-100-05 Tufflon F-100	Norton Safety Products Div.	Neoprene/Nylon
Coat, Style F-100-2310 Tufflon F-100	" " "	Neoprene/Nylon
Coat, 49" Style 92-348 Super Rhind-Lite	" " "	Polyurethane/Nylon
Jacket, 30" Sewn on Hood Style 90-344	" " "	Polyurethane/Nylon
Hooded Jacket Style NSPV-107	" " "	Vinyl/Nylon
Coat, 49" Style NSVP-2348-1	" " "	Vinyl/Nylon
Laboratory Smock Series 3680	Rich Industries	Vinyl
Shop Coat/Splash Re- sistant, Heavy Duty, Style 55-415	Edmont-Wilson Div. Becton, Dickinson & Co.	--
Jacket 32", No. J-340 with zipper, #3 Fabric	Jomac Products, Inc.	Vinyl/Cotton
Coat, basic, 44" No. C-440, Series 610	" " "	Vinyl/Nylon
Fireman's Bunker Coat 60Z, #7500-5	Encon Manufacturing Co.	Neoprene/Nomex
Jacket, Style 5600 #5600-11	" " "	Neoprene, Polyfoam, Nomex-Cotton Lined

Open Back Jacket SD-4499 (Seal tight sleeves) SD-4178	Standard Safety Equipment Co.	Gralite 20
Chemical Jacket(30") SD-4354	" " "	Hi-Glo
Coats/Jackets, Side Closure, SD-3109 SD-4390	" " "	Gralite-20 Hi-Glo
Coats/Jackets, Front Closure, SD-4354 (Seal tight sleeves)	" " "	Hi-Glo
P.O.M (Pyrophoric or- ganic materials) Jacket, SD-4364	" " "	Gralite-20
Switch Pullers Jacket SD-4300 SD-5532	" " "	Gralite-20 Winter Glo-20

PROTECTIVE CLOTHING  
Coveralls/Overalls/Pants

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
Tyvek Coverall (Disposable) No.08-004071-74 small-extra large (full length)	Singer Products Co.	Tyvek (Polyethylene)
Overalls (bib) 3PN-0871	Boss Manufacturing Co.	Vinyl/Nylon
Coverall with Sewn in Body Harness 47073E	Wheeler Protective Apparel, Inc.	
Overall, Acidwear 48536	" " "	Vinyl
Coverall Style F-100- 615, Tufflon F-100	Norton Safety Products Div.	Neoprene/Nylon
Overall, Bib, Style F-100-12	" " "	Neoprene/Nylon
Overall, Bib, Style 91-325, Super Rhino-Lite	" " "	Polyurethane/Nylon
Waist Pant, Style 91-360	" " "	Polyurethane/Nylon
Overall, Style NSPV-12	" " "	Vinyl/Nylon
Coverall, Style 56-15	" " "	Vinyl/Nylon 14-15 oz
JFA Heavy Duty Coverall Style No. 55-510	Edmont-Wilson Div. Bechton, Dickinson & Do.	Polyolefin
Pants, Bib P-010 #3 Fabric	Jomac Products, Inc.	Vinyl/Cotton
Coverall, CO-040 #3 Fabric	" "	Vinyl/Nylon
Coverall, Style 5500 #5500-11	Encon Manufacturing Co.	Neoprene/Polyfoam Nylon/Cotton Lined

Pants, Style 5610  
#5610-11

Encon Manufacturing Co.

Neoprene/Nylon

Coveralls  
SD-3981 (seal-tight  
sleeves)  
SD-4178

Standard Safety Equipment Co.

Gralite-20  
Hi-Glo

Anti-Contamination  
Coverall, SD-574

" " "

Cotton

Air Supplied Coverall  
8 Mil, SD-600

" " "

Plastic (Vinyl)

Bib Overall  
SD-3110  
SD-4046

" " "

Gralite-20  
Hi-Glo

Rocket Fuel  
Handler's Coverall  
SD-3663

" " "

Gralite-20

# PROTECTIVE CLOTHING

## Aprons

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
Bib Apron No. 08-004136	Singer Safety Products, Inc.	Tyvek (Polyethylene)
Apron, Frost Clear	Fabohio, Inc.	Vinyl
Apron (Bib Type) 40136	Wheeler Protective Apparel, Inc.	Vinyl
Apron, Style 54-10	Norton Safety Products Div.	Neoprene/Cotton
Apron, Style 54-30	" " "	Neoprene/Nylon
Apron, Style 34-40	" " "	Hycar Rubber/Cotton
Apron, Style 64-30	" " "	Vinyl/Nylon
Chemgard Plastic Apron Cat. No. 73124 (Med.Weight, 0.008")	Mine Safety Appliances Co.	Vinyl
Synthetic Rubber Coated Apron Cat. No. 37668 (Med. Weight)	" "	Hycar Rubber/Cotton
Synthetic Rubber Coated Apron Cat. No. 31049 (Heavy Weight)	" " "	Buna S Rubber/Cotton
Synthetic Rubber Coated Apron Cat. No. 33441	" " "	Neoprene Rubber/Cotton
Vinyl Coated Apron Cat. No. 37673 (Med. Weight)	" " "	Vinyl/Cotton
Apron, Series 1000	Rich Industries	Vinyl
Heavy Duty 20 Mil Vinyl Apron, 45 #73640, Style 54-733	Edmont Wilson Div. Bector, Dickinson & Co.	Vinyl
Reinforced Heavy Duty Apron, 23 Mil, #72261, Style 54-367	" " "	Hycar

Apron, Bib Style  
AW-3-36, #3 Fabric

Jomac Products, Inc.

Vinyl

Apron, Bib Style

Standard Safety Equipment Co.

Hi-Glo

Apron, Split-Type

" " "

Hi-Glo

# PROTECTIVE CLOTHING

## Suits, Unencapsulating

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
Fire Chemical Suit (new, no part no.)	Fyrepel Products, Inc.	Butyl with aluminized oversuit
Disposable Suit #237 (one piece)	Fabohio, Inc.	Polyethylene, Spun bonded or extended polyethylene
Acid Suit #212 (one piece)	" "	Vinyl
Coverall #47036 (with 15836 Hood)	Wheeler Protective Apparel, Inc.	Vinyl
Two Piece Suit Series 3900	Rich Industries	Vinyl
Acid Suit, Two Piece Series 3675	" "	Vinyl
Heavy Duty Overall JFA	Edmont-Wilson	Polyolefin
Sun-Ray Suit(Two-Piece) Cat.No. 37107 (small) Cat.No. 37108 (medium) Cat.No. 37109 (large)	Mine Safety Appliances Co.	Vinyl/Nylon
Rubber Utility Suit (Two Piece) Cat.No. 32605 (small) Cat.No. 31934 (medium) Cat.No. 32606 (large)	" " "	Synthetic Rubber
Rubberized Protection Suit (One Piece) Cat.No. 33495 (small) Cat.No. 33436 (medium) Cat.No. 33437 (large) hood for above, Cat.No. 33370	" " "	Neoprene
POM Suit, #7550	Encon Manufacturing Co.	Aluminized Nomex

Dust Suit  
SD-2632  
SD-4475

Standard Safety Equipment Co.

Cotton  
Dacron/Rayon

Liquid Oxygen  
Suit, SD-3779

" " "

Whiteside

Two Piece Disposable  
Plastic Suit  
SD-602

" " "

Plastic

PROTECTIVE CLOTHING  
Encapsulating Suit  
(Air Supply/Air Respirator Req'd)

<u>Name and Part No.</u>	<u>Manufacturer</u>	<u>Material</u>
Basic Coverall #CO-910 #2 Chemical Cloth	Jomac Products, Inc.	Vinyl/Nylon
One Piece Suit Zipper, 0.020" Tk. Series 4000	Rich Industries	Vinyl
Rocket Fuel Handler Suit Cat.No. 92682 (Air Supply) Cat.No. 38590 (Air Mask)	Mine Safety Appliances Co.	Vinyl
ChemPruf Suit with Hood Cat. No. 75096 (small) Cat. No. 75097 (medium) Cat. No. 75098 (large)	Mine Safety Appliances Co.	Butyl/Nylon
Disposable Suit, Airfed Cat. No. 91783 (large) Cat. No. 91784 (medium)	" "	Vinyl
Acid King #47836C (with back pouch) #47836H (without pouch)	Wheeler Protective Apparel, Inc.	Vinyl/Betacloth
One Piece Air Supplied Suit #13-20 (0.020")	Fabohio, Inc.	Vinyl
One Piece Air Supplied Suit #13-10, 100Z Nylon	" "	Vinyl/Nylon
Two Piece Air Supplied #15-6, 0.006" Vinyl #15-12, 0.012" Vinyl #15-10, 100Z Nylon	" "	Vinyl Vinyl Vinyl Vinyl/Nylon
Proximity Suit #FD-7599-V	Encon Manufacturing Co.	Neoprene/Nylon
Standard Acidmaster Suit, SD-3711 SD-5520	Standard Safety Equipment Co.	Gralite-20 (Vinyl) Winter Glo-20

Standard Compressed  
Air Suit

Standard Safety Equipment Co.

SD-3896

SD-5542(seal-tight boots)

Gralite-20 (Vinyl)  
Winter Glo-20

Standard Accordian  
Suit

" " "

SD-5196

(Vinyl Overboots)

SD-5256 (Neoprene

Steel Toe Boots)

SD-5563 (Neoprene

Steel Toe Boots)

Gralite 20 (Vinyl)

Gralite 20 (Vinyl)

Winter Glo-20

APPENDIX C  
MATERIAL COMPATIBILITY TEST DATA  
(Task V)

(References listed by number in the tables are included in the Bibliography)

Legend:

- L - Liquid
- S - Solid and soluble
- G - Gas
- M - Slightly soluble
- I - Insoluble
- - Dash indicates no testing performed
- BD - Below detection
- [ ] - Water reactive, pertains to parent compound, literature data
- R - Performance rating based on literature review
- T - Performance rating based on laboratory tests of parent compound or water reaction product
- T-D - Performance rating based on inability to decontaminate
- ND - No data

## INTRODUCTION

A literature search revealed that at least 403 chemicals on the CHRIS list would require a fully encapsulating suit/and or a supplied air or self-contained breathing apparatus. A further review of the literature was conducted to determine whether butyl rubber and polycarbonate, materials used in the Hazardous Chemical Protective Clothing Outfit (HCPCO), were compatible with those chemicals requiring a fully encapsulating suit.

Data on the compatibility of polycarbonate with the chemicals was accepted without further consideration, and compatibility testing was limited to those chemicals for which no compatibility data was available. In the case of butyl rubber, a rating of incompatible was accepted. Additional compatibility testing was conducted when a compatible rating was listed, due to the uncertainty of the test methods used in the past, or when no data was available.

Butyl rubber and polycarbonate were both subjected to 3 hr swatch immersion tests. If gross degradation was observed after the 3 hrs, the materials were judged to be incompatible with the chemical and no further testing was done. When the materials showed no degradation after 3 hrs, they were reexposed for a total of 20 hrs. If no degradation was observed after 20 hrs exposure, polycarbonate was deemed compatible, and butyl rubber was subjected to penetration testing. Decontamination effectiveness of a detergent-water solution (butyl only) was also evaluated.

This Appendix contains information which will be useful for decision making by the On-Site Coordinator in selecting appropriate protective gear for Strike Team personnel. A few examples are given to assist the user in interpreting the information.

Acetaldehyde is a liquid and is not water reactive. Review of the literature (R) indicates that polycarbonate is not compatible with acetaldehyde. Laboratory tests (T) showed that acetaldehyde penetrates butyl rubber in less than 3 hrs exposure. Neither polycarbonate nor butyl rubber is recommended for use with acetaldehyde.

Acetic anhydride is a liquid and reacts with water to form acetic acid. The literature (R) indicates that polycarbonate is compatible with acetic anhydride. The literature also indicates that polycarbonate is compatible with acetic acid, a water reaction product of acetic anhydride. The survey revealed that butyl rubber

is compatible with acetic acid. Polycarbonate and butyl rubber can be used with the parent material, acetic anhydride, and its water reaction product acetic acid.

Acetonitrile is liquid and is not water reactive. Polycarbonate is compatible with acetonitrile according to the literature (R). Butyl rubber was found, in laboratory tests (T), to resist penetration for 6 hrs, but penetration did occur in less than 20 hrs. Polycarbonate can be used with acetonitrile, but butyl rubber will have limited usage, e.g., a single spill cleanup.

Acrylic acid is a liquid and is not water reactive. According to the literature (R), polycarbonate is compatible with acrylic acid. Laboratory tests showed that butyl rubber resisted penetration for up to 20 hrs, but decontamination with a water-detergent solution was ineffective (T-D) in removing acrylic acid from butyl rubber. Polycarbonate and butyl rubber can be used as protective gear during clean up of acrylic acid spills, but due to decontamination problems the butyl suit would be limited to single usage.

Appropriate materials of construction for a protective garment could not be assigned for all 403 chemicals. Additional research is being conducted to determine alternate materials which could be used for a protective garment. As this information becomes available, it is anticipated that the information contained herein will be updated. Meanwhile, On-Site Coordinators and Strike Team personnel should find this information of value in assessing applications of the present HCPCO protective gear.

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST						PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING		
		S T A T E	R E C T I V E	POLYCARB		BUTYL		Tensile	Year	3 hr	20 hr		1	2 hr	3 hr	2 hr	POLYCAR- BONATE	BUTYL
				WEIGHT CHANGE (%)	WEIGHT CHANGE (%)	20 hr PHYS. PROPERTY CHANGE (%)												
							3 hr					20 hr						
AAD	Acetaldehyde	L	N	-	-	-	-	-	-	0.4	-	-	-	-	-	FAIL(R)	FAIL(T)	
AAC	Acetic Acid	L	N	-	-	-	-	-	-	BD	BD	-	-	-	-	PASS(R)	PASS(T)	
ACA	Acetic Anhydride	L	Y	-	FORMS	ACETIC ACID	-	-	-	BD	BD	PASS	-	-	-	[PASS](R)	[PASS](T)	
ACY	Acetone Cyanohydrin	L	N	-	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
ATN	Acetonitrile	L	N	-	-	-	-	-	-	BD	0.9	-	-	-	-	PASS(R)	>6<20 hr(T)	
ABM	Acetyl Bromide	L	Y	-	FORMS	HYDROBROMIC ACID	-	-	-	67	-	-	-	-	-	[PASS](R)	FAIL(T)	
ACC	Acetyl Chloride	L	Y	-	SEE	HYDROCHLORIC ACID	-	-	-	12	-	-	-	-	-	[FAIL](R)	FAIL(T)	
ARL	Acrolein	L	N	-	-	-	-	-	-	1.1	-	-	-	-	-	PASS(R)	FAIL(T)	
AAM	Acrylamide	S	N	-	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
ACR	Acrylic Acid	L	N	-	-	-	-	-	-	BD	BD	FAIL	-	FAIL	-	PASS(R)	FAIL(T-D)	
ACN	Acrylonitrile	L	N	-	-	-	-	-	-	0.4	-	-	-	-	-	PASS(R)	FAIL(T)	
ADN	Adiponitrile	L	N	-	-	-	-	-	-	5	-	-	-	-	-	PASS(R)	FAIL(T)	
ALD	Aldrin	S	I	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(T)	
ALA	Allyl Alcohol	L	N	-	-	-	-	-	-	0.2	-	-	-	-	-	PASS(R)	FAIL(T)	
ALC	Allyl Chloride	L	N	-	-	-	-	-	-	0.2	-	-	-	-	-	FAIL(R)	FAIL(T)	
ATC	Allyl Trichlorosilane	L	Y	-	-	SEE	HYDROCHLORIC ACID	-	-	BD	1.4	-	-	-	-	[FAIL](R)	FAIL(T)	
ACF	Allyl Chloroformate	L	Y	-	-	REACTS SLOWLY IN H <sub>2</sub> O to HCl	-	-	-	83	-	-	-	-	-	[FAIL](R)	FAIL(T)	
ACL	Aluminum Chloride	S	Y	-	-	SEE	HYDROCHLORIC ACID	-	-	-	-	-	-	-	-	[PASS](R)	FAIL(T)	
ALF	Aluminum Fluoride	S	I	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
ALM	Aluminum Sulfate	S	Y	0.0	+0.2	0.0	+0.3	0.0	0.0	-	-	-	-	-	-	PASS(T)	[PASS](R)	
AWA	Ammonia Anhydrous	G	N	-	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
ABF	Ammonium Bifluoride	S	N	-0.1	+0.1	+4.7	+16.1	-	-	-	BD	FAIL	-	-	-	PASS(T)	FAIL(T-D)	
ASU	Ammonium Bisulfite	S	Y	+0.2	+0.5	+0.9	+8.0	-2.0	-1.6	-	BD	FAIL	-	-	-	PASS(T)	FAIL(T)	
ACM	Ammonium Carbamate	S	Y	+0.2	+1.8	+0.7	+0.9	+2.2	+7.3	-	BD	PASS	-	-	-	PASS(T)	PASS(T-D)	
ACH	Ammonium Chromate	S	N	0.0	+0.1	0.0	+0.5	-2.3	-4.5	-	90	PASS	-	-	-	PASS(T)	PASS(T)	

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST						PENETRATION TEST		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING				
		S T A T E	R E C T I V E	POLYCARB		BUTYL				3 hr	20 hr		CYCLES							
				WEIGHT CHANGE (%)	3 hr	20 hr	WEIGHT CHANGE (%)	3 hr	20 hr				Tensile	Tensile	1		2 hr	8		
																			20 hr PHYS. PROPERTY CHANGE (%)	
AMD	Ammonium Dichromate	S	N	-	-	-	-	-	-	-	BD	PASS	-	-	PASS(R)	PASS(T)				
AFB	Ammonium Fluoborate	S	N	+0.1	+0.2	+0.2	+1.7	+2.0	-	-	BD	PASS	-	-	PASS(T)	PASS(T)				
AFR	Ammonium Fluoride	S	N	-	-	-	-	-	-	-	BD	FAIL	-	-	PASS(R)	FAIL(T-D)				
AOX	Ammonium Oxalate	S	N	-	-	-	-	-	-	-	BD	PASS	-	-	PASS(R)	PASS(T)				
ASL	Ammonium Silicofluoride	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)				
ASF	Ammonium Sulfide	L	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)				
ATS	N-Amyl Trichlorosilane	L	N	-	-	-	-	-	-	-	BD	FAIL	-	-	FAIL(R)	FAIL(T)				
ANL	Aniline	L	N	-	-	-	-	-	-	-	BD	FAIL	-	-	FAIL(R)	3 hr(T)				
ASC	Anisoyl Chloride	S/L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL(R)	FAIL(T)				
ATH	Anthracene	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)				
APC	Antimony Pentachloride	L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL(R)	FAIL(T)				
APF	Antimony Pentafluoride	L	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL(T)				
ATM	Antimony Trichloride	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL(T)				
ATT	Antimony Trifluoride	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)				
AZM	Azinphosmethyl	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)				
BCY	Barium Cyanide	S	N	+0.1	+0.2	+0.1	+0.4	+10	-	-	BD	FAIL	-	-	PASS(T)	FAIL(T)				
BZD	Benzaldehyde	L	N	-	-	-	-	-	-	-	BD	3	-	-	FAIL(R)	>6<20 hr(T)				
BWZ	Benzene	L	N	-	-	-	-	-	-	-	BD	1.6	-	-	FAIL(R)	FAIL(T)				
BPT	Benzene Phosphorous Trichloride	L	N	-	-	-	-	-	-	-	BD	BD	-	-	FAIL(T)	FAIL(T)				
BZN	Benzonitrile	L	N	-	-	-	-	-	-	-	BD	BD	-	-	FAIL(n, FA.L(T-D)	FA.L(T-D)				
BBR	Benzyl Bromide	L	N	-	-	-	-	-	-	-	1.5	-	-	-	PASS(R)	FAIL(T)				
BCL	Benzyl Chloride	L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL(R)	FAIL(T)				
BZH	Benzylamine	L	N	-	-	-	-	-	-	-	BD	PASS	-	-	FAIL(R)	PASS(T)				
BEC	Beryllium Chloride	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL(T)				
BEF	Beryllium Fluoride	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)				

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST					PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST CYCLES			TEST PERFORMANCE RATING		
				POLYCARB		BUTYL											
		S T A T E	R E A C T I V E	WEIGHT CHANGE (%)		20 hr PHYS. PROPERTY CHANGE (%)			3 hr	20 hr		1	3 hr	2 hr			
				3 hr	20 hr	3 hr	20 hr	Tensile								Year	
BEN	Beryllium Nitrate	S	Y	-	-	-	SEE NITRIC ACID	-	-	-	-	-	-	-	[PASS(R)] FAIL(T)	FAIL(T)	
BEO	Beryllium Oxide	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
BEM	Beryllium, Metallic	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
BES	Beryllium, Sulfate	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
BPA	Bisphenol A	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
BDE	Bisphenol A Diglycidyl Ether	L	N	-	-	-	UNAVAILABLE	-	-	-	-	-	-	-	ND	ND	
BCP	Boiler Compound, Liquid	L	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
BTB	Boron Tribromide	L	Y	-	-	-	FORMS HYDROBROMIC ACID	-	-	-	-	-	-	-	[PASS(R)] [FAIL(T)]	FAIL(T)	
BRT	Boron Trichloride	L	Y	-	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	[FAIL(R)] [FAIL(T)]	FAIL(T)	
BRM	Bromine	L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL(R)	FAIL(R)	
BPF	Bromine Pentafluoride	L	Y	-	-	-	SEE HYDROFLUORIC ACID	-	-	-	-	-	-	-	[FAIL(R)] [FAIL(T)]	FAIL(T)	
BTF	Bromine Trifluoride	L	Y	-	-	-	SEE HYDROFLUORIC ACID	-	-	-	-	-	-	-	ND	FAIL(T)	
BHP	Tert-Butyl Hydroperoxide	L	N	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
BAM	N-Butyl Amine	L	N	-	-	-	-	-	800	-	-	-	-	-	FAIL(R)	FAIL(T)	
BTO	1,2-Butylene Oxide	L	N	-	-	-	-	-	>30	-	-	-	-	-	PASS(R)	FAIL(T)	
BCS	Butyl Trichlorosilane	L	Y	-	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	[FAIL(R)] [FAIL(T)]	FAIL(T)	
BTD	1,4-Butynediol	S	N	-	-	-	-	-	BD	BD	PASS	-	-	-	FAIL(R)	PASS(T)	
BAD	ISO-Butraldehyde	L	N	-	-	-	-	-	1.7	-	-	-	-	-	FAIL(T)	FAIL(T)	
BTR	N-Butraldehyde	L	N	-	-	-	+7.7 +12.5	-	36	-	-	-	-	-	FAIL(R)	FAIL(T)	
CAT	Cadmium Acetate	S	N	-	-	-	FOGGED	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
CMB	Cadmium Bromide	S	N	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS(T)	
LDC	Cadmium Chloride	S	N	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS(T)	
CFB	Cadmium Fluoborate	L	N	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS(T)	
CMN	Cadmium Nitrate	S	N	-	-	-	-0.3 -0.3	+2.9	SEE CADMIUM COMPOUNDS	-	-	-	-	-	PASS(R)	PASS(T)	
COX	Cadmium Oxide	S	I	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS(R)	

CHRIS CODE	CHEMICAL NAME	STATE	WATER		SWATCH TEST							PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING	
			S	T	POLYCARB		BUTYL								CYCLES	3 hr	2 hr		
					HEIGHT CHANGE (%)	WEIGHT CHANGE (%)	20 hr PHYS. PROPERTY CHANGE (%)			1	8								
							3 hr	20 hr	3 hr			20 hr	Tensile					Tear	
														3 hr	20 hr				
CMS	Cadmium Sulfate	S	N	-	-	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS(T)	
CCA	Calcium Arsenate	S	I	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
CAS	Calcium Arsenite	S	I	-	-	-	-	-	-	-	-	-	-	-	-	-	NO	NO	
CCR	Calcium Chromate	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
CCN	Calcium Cyanide	S	-	-	-	-	DECOMPOSES	-	-	-	-	-	-	-	-	-	[PASS](R)	[PASS](R)	
CAF	Calcium Fluoride	S	I	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
CPT	Captan	S	I	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
CBO	Carbolic Oil	L	-	-	-	-	SEE PHENOL	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
CBB	Carbon Disulfide	L	-	-	-	-	+74	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
CTC	Catechol	S	S	-	-	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
CPS	Caustic Potash Solution	L	-	-	-	-	-	-	-	-	BD	BD	PASS	-	-	-	FAIL(R)	PASS(T)	
CSS	Caustic Soda Solution	L	-	-	-	-	-	-	-	-	BD	BD	PASS	-	-	-	FAIL(R)	PASS(T)	
CDM	Chlordane (liquid formulation)	L	-	-	-	-	SEE KEROSENE - INCOMPATIBLE	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL(R)	
CLX	Chlorine	G	-	-	-	-	SEE HYDROFLUORIC ACID	-	-	-	BD	BD	(DISCOLORED)	-	-	-	PASS(R)	FAIL(T)	
CTF	Chlorine Trifluoride	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[PASS](R)	FAIL(T)	
CTD	4-Chloro-0-Toluidine	S	M	N	FAILED	+0.6	+3.3	+2.3	+5.7	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
CRA	Chloroacetophenone	S	I	N	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
CAC	Chloroacetyl Chloride	L	-	-	-	-	SEE HYDROFLUORIC ACID	-	-	-	-	-	-	-	-	-	[FAIL](R)	FAIL(R)	
CAP	P-Chloroaniline	S	S	N	-	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	
CBM	4-Chlorobutronitrile	L	-	N	FAILED	+2.5	+5.7	+1.1	+3.7	-	BD	BD	PASS	-	-	-	FAIL(T)	PASS(T)	
CRF	Chloroform	L	-	N	FAILED	+9.0	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
CHD	Chlorohydrin (Crude)	L	-	N	+0.2	+0.1	+1.6	+8.0	+4.8	-	BD	BD	PASS	-	-	-	PASS(T)	PASS(T)	
CME	Chloromethyl Methyl Ether	L	-	N	FAILED	FAILED	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
CNO	O-Chloronitrobenzene	S	I	N	-	-	-	-	-	-	-	-	-	-	-	-	NO	NO	
CPN	P-Chlorophenol	S	M	N	-	-	-	-	-	-	BD	BD	PASS	-	-	-	PASS(R)	PASS(T)	

CHRIS CODE	CHEMICAL NAME	S T A T E	WATER	SWATCH TEST						PENETRATION TEST ppm or mg*	SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING	
				POLYCARB	WEIGHT CHANGE (%)	WEIGHT CHANGE (%)	20 hr PHYS. PROPERTY CHANGE (%)	BUTYL	3 hr			20 hr	3 hr	2 hr	POLYAR- BONATE	BUTYL
3 hr	20 hr	Tensile	Tear													

CHM	Cyclohexanol	L	N	-	-	-	-	-	-	BD	PASS	-	-	-	PASS (R)	PASS (T)
CHP	Cyclohexanone Peroxide	L	N	-	-	-	-	-	-	BD	PASS	-	-	-	PASS (R)	PASS (T)
CHT	Cyclohexynyltrichlorosilane	L	Y	-	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	[FAIL] (R)	FAIL (T)
CHA	Cyclohexylamine	L	N	-	-	-	-	-	-	44	-	-	-	-	FAIL (R)	FAIL (T)
DAL	Decaldehyde	L	N	-	-	-	-	-	-	SEE XYLENE (INCOMPATIBLE)	-	-	-	-	FAIL (R)	FAIL (T)
DTN	Demeton (liquid formulation)	L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL (R)	FAIL (T-D)
DEP	DI-(2-Ethylhexyl) Phosphoric Acid	L	N	-	-	-	-	-	-	BD	FAIL	PASS	FAIL	-	PASS (R)	NO
DZP	DI-(P-Chlorobenzoyl) Peroxide	L	N	-	-	-	-	-	-	-	-	-	-	-	NO	FAIL (T)
DBA	DI-N-Butylamine	L	N	-	-	-	-	-	-	2.4	-	-	-	-	FAIL	-
DNA	DI-N-Propylamine	L	N	-0.1	FOG	+61	-	-	-	-	-	-	-	-	FAIL (T)	FAIL (T)
DZN	Diazinon	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)
DBT	Bibutylphenol	S	N	-	-	-	-	-	-	-	-	-	-	-	NO	NO
DBO	O-Dichlorobenzene	L	N	-	FOGGED	-	-	-	-	936	-	-	-	-	FAIL (T)	FAIL (T)
DCB	Dichlorobutene	L	N	-	FOGGED	+17	+19	-5.6	+11	-	-	-	-	-	FAIL (T)	FAIL (T)
DEE	Dichloroethyl Ether	L	N	-	FOGGED	+3.8	+11.0	-2.5	+1.1	-	-	-	-	-	FAIL (T)	FAIL (T)
DCP	2,4-Dichlorophenol	S	M	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)
DPP	1,2-Dichloropropane	L	N	-	-	-	-	-	-	>5	-	-	-	-	FAIL (R)	FAIL (T)
DCV	Dichlorvos (liquid formulation)	L	N	-	FOGGED	+42	-	-	-	-	-	-	-	-	FAIL (T)	FAIL (T)
DPT	Dicyclopentadiene	S	I	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)
DEO	Diethrin	S	I	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS
DFA	Diisopropylphosphoric Acid(anhydrous)	L	Y	-	-	-	SEE HYDROFLUORIC ACID	-	-	-	-	-	-	-	[FAIL] (R)	FAIL (T)
DIH	Diisopropylbenzene Hydroperoxide	L	N	-	FOGGED	+24	+29	-	-	-	-	-	-	-	FAIL (T)	FAIL (T)
DSF	Dimethyl Sulfate	L	N	-	-	-	-	-	-	BD	FAIL	PASS	PASS	-	PASS (R)	PASS (T)
DSL	Dimethyl Sulfide	L	N	-	-	-	-	-	-	27	-	-	-	-	PASS (R)	FAIL (T)

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST						PENETRATION TEST		SINGLE DECON TEST	MULTIPLE DECON TEST		TEST PERFORMANCE RATING	
		S T A T E	S O L U B.	POLYCARB		BUTYL				ppm or mg*	CYCLES		POLYCARBONATE	BUTYL		
				3 hr	20 hr	3 hr	20 hr	20 hr	Year							
															WEIGHT CHANGE (%)	WEIGHT CHANGE (%)
CPL CRP CSA CRT CMA	Chloropicrin Chloroprene Chlorosulfonic Acid Chromic Acetate Chromic Anhydride (wet)	L L L S S	N N Y N N	- - - +0.1 -	- - - +0.2 -	- - - +1.5 -	- - - +1.1 -	- - - 0.0 -	- - - 0.0 -	10 - - - -	- - - - -	- - - - -	- - - - -	PASS (R) ND FAIL (T) PASS (T) PASS (R)	PASS (R) FAIL (T) PASS (T) PASS (R)	
CHS CRC CMC COF CAA	Chromic Sulfate Chromous Chloride Chromyl Chloride Cobalt Fluoride(ous) Copper Acetoarsenite(1c)	S S L S S	N N Y N N	- 0.0 +0.2 - -	+0.1 +0.1 - +0.2 -	+0.1 +0.1 - +0.2 -	+1.0 +1.0 - +0.7 -	-3.7 -4.9 -1.1 +1.4 -	- - - - -	SEE CHROMIC ACETATE BD BD BD -	- - - - -	- - - - -	- - - - -	FAIL (T) PASS (T) ND PASS (T) PASS (R)	PASS (T) PASS (T) PASS (T) PASS (T) PASS (R)	
CPA CCY CPF CDL CSN	Copper Arsenite(1c) Copper Cyanide Copper Fluoborate(1c) Copper Oxalate(1c) Copper Sulfate(1c)Ammoniated	S S L S S	N N N N N	- - -0.6 - +0.1	- - -0.6 +0.2 +0.2	- - -1.2 0.0 +0.3	- - -1.1 -0.5 +1.1	- - -0.5 +1.0 +1.1	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	PASS (R) PASS (R) PASS (T) PASS (R) PASS (T)	PASS (R) PASS (R) PASS (T) PASS (R) PASS (T)	
COU CCT CTA CUM CMI	Cumaphos Creosote, Coal Tar Crotonaldehyde Cumene Cumene Hydroperoxide	S L L L L	N N N N N	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- BD BD 195 -	- BD BD 6.8 -	- BD BD 6.8 -	- BD BD 6.8 -	- BD BD 6.8 -	ND PASS (R) FAIL (R) PASS (R) PASS (R)	ND PASS (R) FAIL (R) PASS (R) PASS (R)
CES CYA CYG CER CCL	Cupriethylenediamine Solution Cyanoacetic Acid Cyanogen Cyanogen Bromide Cyanogen Chloride	L L L G G	N N N N Y	0.0 - - - -	0.0 - - - -	+3.3 - - - -	+6.8 - - - -	-9.5 - - - -	-10.3 - - - -	- BD BD BD 0.7	- BD BD BD -	- BD BD BD -	- BD BD BD -	- BD BD BD -	PASS (T) PASS (R) PASS (R) PASS (R) [PASS](R)	FAIL (T) PASS (R) PASS (R) PASS (R) PASS (R)

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST						PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING	
				POLYCARB		BUTYL											
		S T A T E	R E A C T I V E	WEIGHT CHANGE (%)		WEIGHT CHANGE (%)		20 hr PHYS. PROPERTY CHANGE (%)		3 hr	20 hr		1	2 hr	8	POLYCAR- BOMATE	BUTYL
				3 hr	20 hr	3 hr	20 hr	Tensile	Tear								
DAC	Dimethyl Acetamide	L	N	-	-	-	-	-	-	0.9	-	-	-	-	FAIL(R)	FAIL(T)	
DDW	Dimethylhexane Dihydroperoxide, Met	S	M	-	-	-	-	-	-	BD	BD	-	-	PASS	PASS(T)	PASS(T)	
DMG	Dimethyldichlorosilane	L	N	-	-	-	-	-	-	-	-	-	-	-	[FAIL(R)]	FAIL(T)	
DMH	1,1-Dimethyldiazine	L	N	-	-	-	-	-	-	BD	BD	-	-	-	FAIL(R)	FAIL(T-0)	
DNZ	Dinitrobenzene	S	I	-	-	-	-	-	-	-	-	-	-	-	ND	ND	
DNB	Dinitrobenzene, Meta	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
DNC	Dinitroresols	S	M	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
DNP	2,4-Dinitrophenol	S	M	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
DTT	2,4-Dinitrotoluene	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
DAM	Diphenylamine	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
DPD	Diphenyldichlorosilane	L	N	-	-	-	-	-	-	-	-	-	-	-	3 hr(T)	FAIL(T)	
DPM	Diphenylmethane Diisocyanate	L	N	-	-	-	-	-	-	-	-	-	-	-	[PASS(R)]	[PASS(R)]	
DIQ	Diquat (liquid formulation)	L	N	-	-	-	-	-	-	BD	BD	-	-	PASS	PASS(T)	PASS(T)	
DIS	Disulfiton (liquid formulation)	L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
DIU	Diuron (water suspension)	L	M	-	-	-	-	-	-	-	-	-	-	-	PASS(T)	FAIL(T)	
DDB	Dodecylbenzene	L	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL(T)	
DTC	Dodecyltrichlorosilane	L	N	-	-	-	-	-	-	-	-	-	-	-	[FAIL(R)]	FAIL(T)	
DUR	Dursban (liquid formulation)	L	N	-	-	-	-	-	-	-	-	-	-	-	ND	ND	
ESF	Endosulfane	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
EDR	Endrin	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
EPC	Epichlorohydrin	L	N	-	-	-	-	-	-	BD	1	-	-	FAIL	PASS(R)	FAIL(T-0)	
ETO	Ethion	L	N	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
EAC	Ethyl Acrylate	L	N	-	-	-	-	-	-	11.3	-	-	-	-	FAIL(R)	FAIL(T)	
ECF	Ethyl Chloroformate	L	N	-	-	-	-	-	-	54	-	-	-	-	FAIL(T)	FAIL(T)	
ETM	Ethyl Methacrylate	L	N	-	-	-	-	-	-	300	-	-	-	-	FAIL(R)	FAIL(T)	

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST				PENETRATION TEST		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING		
		S T A T E	S O L U B.	R E A C T I V E	POLYCARB	BUTYL		3 hr	20 hr		3 hr	2 hr	8	POLYCAR- BONATE	BUTYL	
						WEIGHT CHANGE (%)	20 hr PHYS. PROPERTY CHANGE (%)									
										3 hr						20 hr
EPD	Ethyl Phosphorothioic Dichloride Anhydrous	L	N	N											FAIL (T)	
EPP	Ethyl Phosphorodichloridate	L	N	N											FAIL (T)	
EAM	Ethyl Amine	L	N	N											FAIL (T)	
ECS	Ethylchlorosilane	L	N	N											FAIL (R)	
ECH	Ethylene Chlorohydrin	L	N	N											FAIL (R)	
ETC	Ethylene Cyanohydrin	L	N	N											PASS (T)	
EDB	Ethylene Dibromide	L	N	N											PASS (R)	
EDC	Ethylene Dichloride	L	N	N											PASS (R)	
EOX	Ethylene Oxide	L	N	N											PASS (R)	
ETI	Ethyleneimine	L	N	N											PASS (R)	
EHA	Ethylhexaldehyde	L	N	N											[FAIL] (R)	
EAI	2-Ethylhexyl Acrylate	L	N	N											FAIL (T)	
ENB	Ethylidenenorbornene	L	N	N											FAIL (R)	
EPS	Ethylphenyl Dichlorosilane	L	N	N											PASS (T)	
ETS	Ethyltrichlorosilane	L	N	N											FAIL (T)	
FAO	Ferric Ammonium Oxalate	S	N	N											FAIL (R)	
FCL	Ferric Chloride	S	N	N											[FAIL] (R)	
FFX	Ferric Fluoride	S	N	N											FAIL (R)	
FFB	Ferrous Fluoborate	L	N	N											PASS (R)	
FOX	Ferrous Oxalate	S	N	N											PASS (R)	
FXX	Fluorine	G	N	N											PASS (R)	
FSL	Fluosilicic Acid	L	N	N											NO	
FSA	Fluosulfonic Acid	L	N	N											FAIL (T)	
FMS	Formaldehyde Solution	L	N	N											PASS (R)	
GTA	Glutaldehyde Solution	L	N	N											PASS (R)	



CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST								PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST CYCLES			TEST PERFORMANCE RATING
				POLYCARB		BUTYL												
		S T A T E	R E A C T I V E	WEIGHT CHANGE (%)		WEIGHT CHANGE (%)		20 hr PHYS. PROPERTY CHANGE (%)										
				3 hr	20 hr	3 hr	20 hr	Tensile	Tear	3 hr	20 hr							
IPM	Isopropyl Mercaptan	L	N	-	-	-	-	-	-	-	1020	-	-	-	-	PASS (R)	FAIL (T)	
IPP	Isopropylamine	L	N	-	-	-	-	-	-	-	BD	-	-	-	PASS	FAIL (R)	PASS (T)	
IYA	Isovaleraldehyde	L	N	-	-	-	-	-	-	-	0.8	-	-	-	-	ND	FAIL (T)	
KPE	Kepone	S	M	-	-	-	-	-	-	-	-	-	-	-	-	PASS (K)	ND	
LPO	Lauroyl Peroxide	S	I	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
LPM	Lauryl Mercaptan	L	N	-	-	-	-	-	-	-	ATTACKED	-	-	-	-	PASS (R)	FAIL (T)	
LAC	Lead Acetate	S	N	-	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
LFB	Lead Fluoborate	L	N	-	-	-	-	-	-	-	-	-	-	-	-	PASS (T)	PASS (T)	
LAR	Lead Arsenate	S	I	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
LFR	Lead Fluoride	S	I	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
LSA	Lead Stearate	S	I	N	-	-	-	-	-	-	-	-	-	-	-	NO	NO	
LTT	Lead Tetraacetate	S	D	Y	-	-	-	-	-	-	-	-	-	-	-	[PASS] (R)	[PASS] (R)	
LBC	Lithium Bichromate	S	S	M	+0.1	+0.4	-0.2	+0.3	+1.0	+1.0	-	-	-	-	-	PASS (T)	FAIL (T)	
LGR	Lithium Chromate	S	S	N	+0.1	+0.2	0.0	+0.2	+0.3	+6.0	-	-	-	-	-	PASS (T)	PASS (T)	
MLT	Malathion	L	N	-	-	-	-	-	-	-	BD	-	-	-	FAIL	PASS (R)	FAIL (T)	
MLI	Maleic Acid	S	S	N	-	-	-	-	-	-	BD	-	-	-	-	PASS (R)	PASS (T)	
MLA	Maleic Anhydride	S	S	Y	-	-	-	-	-	-	BD	-	-	-	-	[PASS] (R)	PASS (T)	
MLH	Maleic Hydrazide	S	S	M	N	-	-	-	-	-	-	-	-	-	-	ND	ND	
MAT	Mercuric Acetate	S	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (T)	
MCC	Mercuric Ammonium Chloride	S	S	M	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
MRC	Mercuric Chloride	S	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
MCN	Mercuric Cyanide	S	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
MID	Mercuric Iodide	S	S	I	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	
MNT	Mercuric Nitrate	S	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (T)	
MOX	Mercuric Oxide	S	S	I	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)	

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST					PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING	
				POLYCARB		BUTYL										
		S T A T E	R E C T I V E	WEIGHT CHANGE (%)		WEIGHT CHANGE (%)		20 hr PHYS. PROPERTY CHANGE (%)		3 hr		20 hr	1	8	2 hr	POLYCAR- BONATE
				3 hr	20 hr	3 hr	20 hr	Tensile	Tear							
MRS	Mercuric Sulfate	S	D	+0.1	+0.5	+2.8	+0.5	+7.0	-	BD	PASS	-	-	-	PASS(T)	PASS (T)
MSF	Mercuric Sulfide	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS (R)
MRT	Mercuric Thiocyanate	S	I	-	-	-	-	-	-	-	-	-	-	-	ND	ND
MRR	Mercurous Chloride	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS (R)
MRN	Mercurous Nitrate	S	S	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS (T)
MCR	Mercury	L	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS (R)
MSO	Mesityl Oxide	L	-	-	-	-	-	-	0.5	-	-	-	-	-	PASS(R)	FAIL (T)
MAA	Methyl Amyl Alcohol	L	-	-	-	-	-	-	BD	BD	FAIL	-	-	-	PASS(R)	FAIL (T-D)
MTB	Methyl Bromide	G	M	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL (R)
MCH	Methyl Chloroformate	L	-	-	-	-	-	-12.0	-	-	-	-	-	-	FAIL(T)	FAIL (T)
MCS	Methyl Dichlorosilane	L	-	-	-	-	-	-	-	-	-	-	-	-	[FAIL(R)	FAIL (T)
MHZ	Methyl Hydrazine	L	-	-	-	-	-	-	BD	BD	FAIL	-	-	-	FAIL(T)	FAIL (T-D)
MIC	Methyl Isobutyl Carbinol	L	-	-	-	-	-	-6.0	BD	BD	FAIL	-	-	-	PASS(R)	FAIL(T-D)
MPK	Methylisopropenyl Ketone (inhibited)	L	-	-	-	-	-	-	BD	BD	FAIL	-	-	-	ND	ND
MPT	Methyl Parathion	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS (R)
MVK	Methyl Vinyl Ketone	L	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL (T)
MAM	Methyl Acrylate	L	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL (T)
MTA	Methylamine (water solution)	L	S	-	-	-	-	-	BD	BD	FAIL	-	-	-	FAIL(R)	PASS (T)
MAN	N-Methylaniline	L	-	-	-	-	-	-	BD	BD	FAIL	-	-	-	PASS(R)	FAIL(T-D)
MCT	Methylcyclopentadienylmanganese Tri-carbonyl	L	I	-	-	-	-	-	-	-	-	-	-	-	ND	ND
MVK	Methyl Vinyl Ketone	L	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL (T)
MAM	Methyl Acrylate	L	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL (T)
MTA	Methylamine (water solution)	L	S	-	-	-	-	-	BD	BD	FAIL	-	-	-	FAIL(R)	PASS (T)
MAN	N-Methylaniline	L	-	-	-	-	-	-	BD	BD	FAIL	-	-	-	PASS(R)	FAIL(T-D)
MCT	Methylcyclopentadienylmanganese Tri-carbonyl	L	I	-	-	-	-	-	-	-	-	-	-	-	ND	ND
MPD	Methylphosphonothioic Dichloride Anhydrous	L	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL (T)
MPY	1-Methylpyrrolidone	L	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL (T)
MIS	Methyltrichlorosilane	L	-	-	-	-	-	-	-	-	-	-	-	-	[FAIL(R)	FAIL (T)
MRX	Mirex	S	I	-	-	-	-	-	-	-	-	-	-	-	ND	ND
MFA	Motor Fuel AntiKnock CMPDS (PB Alkyls)	L	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)	FAIL (T)

CHRIS CODE	CHEMICAL NAME	S T A T E	WATER	SWATCH TEST						PENETRATION TEST ppm or mg*	SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING		
				POLYCARB		BUTYL		Tensile	Tear			3 hr	2 hr	3 hr	2 hr	POLYCAR- BOMATE	BUTYL
				WEIGHT CHANGE (%)	WEIGHT CHANGE (%)	20 hr. HYS. PROPERTY CHANGE (%)											
							3 hr										
NAB	Habam (liquid formulation)	L	N	-	-	-	-	-	-	BD	BD	-	-	-	PASS (R) ND	PASS (T) ND	
NLD	Maled	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (T) ND	FAIL (T) ND	
NCT	Naphtha, Coal Tar	L	N	+0.1	+0.1	FAILED	FAILED	-	-	-	-	-	-	-	FAIL (T) ND	FAIL (T) ND	
NSV	Naphtha, Solvent	L	N	FOGGED	-	-	-	-	-	-	-	-	-	-	FAIL (T) ND	FAIL (T) ND	
NAO	Naphthylamine	S	M	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
NCN	Nickel Cyanide	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
HFB	Nickel Fluoborate	L	N	0.0	-0.4	+0.1	+0.9	-7.0	-4.0	-	BD	-	-	-	PASS (T) ND	PASS (T) ND	
NFM	Nickel Formate	S	S	-	-	-	-	-	-	-	BD	-	-	-	PASS (R) ND	PASS (T) ND	
NKH	Nickel Hydroxide	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (T) ND	
NNI	Nickel Nitrate	S	I	-	-	-	-	-	-	-	BD	-	-	-	PASS (R) ND	PASS (T) ND	
NKS	Nickel Sulfate	S	I	-	-	-	-	-	-	-	BD	-	-	-	PASS (R) ND	PASS (T) ND	
NIC	Nicotine	L	N	-	-	-	-	-	-	0.7	-	-	-	-	PASS (R) ND	FAIL (T) ND	
NCS	Nicotine Sulfate	S	S	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
NIL	Nitralin	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
NAC	Nitric Acid	L	N	YELLOW	FAILED	-	-	-	-	-	-	-	-	-	FAIL (T) ND	FAIL (T) ND	
NTX	Nitric Oxide	L	N	-	-	-	-	-	-	-	-	-	-	-	[PASS (R) ND]	FAIL (T) ND	
NAA	Nitrotriacetic Acid and Salts	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
NTA	2-Nitroaniline	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
NAL	4-Nitroaniline	S	I	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	PASS (R) ND	
NTB	Nitrobenzene	L	N	FAILED	+4.2	+15	-10.2	+6.5	-	-	-	-	-	-	FAIL (T) ND	FAIL (T) ND	
NOX	Nitrogen Tetraoxide	L	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R) ND	FAIL (T) ND	
NTC	Nitrosyl Chloride	L	N	-	-	-	-	-	-	-	-	-	-	-	[PASS (R) ND]	FAIL (T) ND	
MPP	2-Nitropropane	L	N	-	-	-	-	-	-	BD	BD	-	-	-	PASS (R) ND	FAIL (T) ND	
MIE	O-Nitrotoluene	L	N	FAILED	+9.9	+15.2	-	-	-	-	-	-	-	-	FAIL (T) ND	FAIL (T) ND	

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST						PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING	
				POLYCARB		BUTYL							CYCLES				
		S	T	WEIGHT CHANGE (%)		20 hr PHYS. PROPERTY CHANGE (%)				3 hr	20 hr		1	3 hr	2 hr	POLYCARBONATE	BUTYL
				3 hr	20 hr	3 hr	20 hr	Tensile	Tear								
NTT	P-Nitrotoluene	S	I	+0.1	+0.2	+0.2	+2.0	0.0	-4.0	-	BD	PASS	-	-	PASS(T)	PASS(T)	
NMP	Nonyl Phenol	L	N	-	-	-	-	-	-	BD	PASS	-	-	-	FAIL(R)	PASS(T)	
OCR	Oil, Miscellaneous, Croton	L	N	-	-	-	-	-	-	-	-	-	-	-	ND	FAIL(R)	
OLM	Oleum	L	Y	-	-	SEE SULFURIC ACID	-	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
OXA	Oxalic Acid	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	ND	
PTC	Parathion	L	N	-	-	-	-	-	-	BD	PASS	-	-	-	PASS(R)	PASS(T)	
PCP	Pentachlorophenol	S	M	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
PAA	Peracetic Acid	L	N	-	-	-	-	-	-	3.6	-	-	-	-	PASS(R)	FAIL(T)	
PCL	Perchloric Acid	L	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
PCM	Perchloromethyl Mercaptan	L	N	-	-	-	-	-	-	9	-	-	-	-	FAIL(R)	FAIL(T)	
PTL	Petrolatum	L	N	-	-	-	-	-	-	ATTACKED	-	-	-	-	PASS(R)	FAIL(T)	
PHM	Phenol	S	S	-	-	-	-	-	-	>0.2	-	-	-	-	FAIL(R)	FAIL(T)	
PDL	Phenyldichloroarsine, Liquid	L	Y	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	-	FAIL(R)	FAIL(T)	
PHI	Phenyldiazine Hydrochloride	S	N	-	-	-	-	-	-	BD	PASS	-	-	-	FAIL(R)	PASS(T)	
PHD	Phosdrin	L	N	-	-	-	-	-	-	BD	BD	PASS	-	-	FAIL(T)	PASS(T)	
PHG	Phosgene	L	D	-	-	+2.1	+4.4	-8.1	-8.0	-	-	-	-	-	PASS(R)	FAIL(T)	
PPO	Phosphorous Oxichloride	L	Y	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	-	PASS(R)	FAIL(T)	
PPP	Phosphorous Pentasulfide	S	D	-	-	-	-	-	-	-	-	-	-	-	[PASS(R)]	FAIL(T-D)	
PBF	Phosphorous Tribromide	L	Y	-	-	FAILED	FAILED	-	-	-	-	-	-	-	FAIL(T)	FAIL(T)	
PPT	Phosphorous Trichloride	L	Y	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	FAIL(T)	
PCB	Polychlorinated Biphenyls	L	N	-	-	-	-	-	-	UNAVAILABLE	-	-	-	-	PASS(R)	PASS(R)	
PBO	Potassium Binoxalate	S	S	-	-	-	-	-	-	UNAVAILABLE	-	-	-	-	PASS(R)	PASS(R)	
PCH	Potassium Chromate	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS(R)	PASS(R)	
PTC	Potassium Cyanide	S	Y	-	-	-	-	-	-	-	BD	FAIL	-	-	PASS(R)	FAIL(T-D)	



CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST					PENETRATION TEST ppm or mg*			SINGLE DECON TEST	MULTIPLE DECON TEST			TEST PERFORMANCE RATING	
				POLYCARB		BUTYL		3 hr					20 hr	Tensile	Tear		
		S T A T E	S O L U B	WEIGHT CHANGE (%)		20 hr PHYS. PROPERTY CHANGE (%)											
				3 hr	20 hr	3 hr	20 hr	Wt Change (%)	Phys. Change (%)	1	3 hr	2 hr	8				
SML	Sodium Methylate	S	D	-	-	-	DECOMPOSES	-	-	-	-	-	-	-	-	-	[PASS](R)
SOL	Sodium Oxalate	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)
SSE	Sodium Selenite	S	S	+0.2	+0.3	+0.2	+1.2	-3.0	+6.0	-	-	-	-	-	-	-	PASS(T)
SFR	Sodium Silicofluoride	S	S	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)
SDS	Sodium Sulfide	S	S	-	-	+3.9	+5.5	-12.4	-7.8	-	-	-	-	-	-	-	PASS(R)
STF	Stannous Fluoride	S	S	+0.1	+0.2	+0.3	+0.7	+2.0	+7.3	-	-	-	-	-	-	-	PASS(T)
SOH	Strontium Chromate	S	I	-	-	-	-	-	-	-	-	-	-	-	-	-	ND
STR	Strychnine	S	H	-	-	-	-	-	-	-	-	-	-	-	-	-	ND
SXA	Sulfur (liquid) @ 113-120°C	S	H	-	-	-	-	-	-	-	-	-	-	-	-	-	ND
SFD	Sulfur Dioxide	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[PASS](R)
SFM	Sulfur Monochloride	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[FAIL](R)
SFA	Sulfuric Acid	L	S	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)
SAC	Sulfuric Acid (spent)	L	S	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)
SCL	Sulfuryl Chloride	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)
TES	2,4,5-T Esters (liquid formulation)	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)
TEC	Tetrachloroethane	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)
TED	Tetraethyl Dithiopyrophosphate	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[PASS](R)
TEL	Tetraethyl Lead	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(R)
TEP	Tetraethyl Pyrophosphate	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	PASS(R)
TTP	Tetraethylenepentamine	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)
THF	Tetrahydrofuran	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(R)
THL	Tetramethyl Lead	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	FAIL(T)
TPG	Triphenylene	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[PASS](R)
TTT	Titanium Tetrachloride	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ND
TOI	Toluene 2,4-Diisocyanate	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[PASS](R)

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST				PENETRATION TEST ppm or mg*		SINGLE DECOM TEST	MULTIPLE DECOM TEST			TEST PERFORMANCE RATING		
				POLYCARB		BUTYL										
		S T A T E	S O L U B.	R E C T I V E	WEIGHT CHANGE (%)	WEIGHT CHANGE (%)	20 hr PHYS. PROPERTY CHANGE (%)		3 hr		20 hr	CYCLES	3 hr	2 hr	POLYCAR- BONATE	BUTYL
							Tensile	Tear								
TAP	P-Toluene Sul'onic Acid	S	S	N	0.0	0.0	+4.7	+5.5	-32.2	-12	-	-	-	-	PASS (T)	FAIL(T)
TXP	Toxaphene	S	S	I	N	N	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)
TRC	Trichlorofen (liquid formulation)	L	S	N	0.0	0.0	+1.9	+6.0	-6.7	-6.8	BD	BD	-	-	PASS (T)	PASS (T)
TCL	Trichloroethylene	L	S	N	0.0	0.0	FAILED	FAILED	-	-	-	-	-	-	FAIL (T)	FAIL (T)
TPH	Trichloropheno1	S	M	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)
TCA	2,4,5-Trichlorophenoxyacetic Acid	S	I	N	-	-	-	-	-	-	-	-	-	-	ND	ND
TEN	Triethylamine	L	N	N	-	-	-	-	-	-	-	-	-	-	FAIL (R)	FAIL(T)
TEB	Triethylbenzene	L	N	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	FAIL(T)
TET	Triethylenetetramine	L	N	N	-	-	-	-	-	-	BD	BD	-	-	FAIL (R)	PASS (T)
TMA	Trimethylamine (water solution)	G	S	N	-	-	-	-	-	-	0.6	0.6	-	-	FAIL (R)	FAIL(T)
TMC	Trimethylchlorosilane	L	N	Y	0.0	0.0	FAILED	NOT AVAILABLE	-	-	-	-	-	-	PASS (T)	FAIL(T)
TPO	Tris(azididiny)lphosphine Oxide	S	N	N	-	-	-	-	-	-	-	-	-	-	ND	ND
URP	Uranium Peroxide	S	I	N	-	-	-	-	-	-	-	-	-	-	ND	ND
UAN	Uranyl Nitrate	S	N	N	-	-	-	-	-	-	-	-	-	-	ND	ND
URS	Uranyl Sulfate	S	N	N	-	-	-	-	-	-	-	-	-	-	ND	ND
VOT	Vanadium Oxytrichloride	-	Y	N	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	[FAIL](R)	FAIL(T)
VSF	Vanadyl Sulfate	S	N	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	ND
VCM	Vinyl Chloride	G	N	N	-	-	-	-	UNAVAILABLE	-	-	-	-	-	PASS (R)	ND
VFI	Vinyl Fluoride (inhibited)	G	N	N	+0.1	+0.1	0.0	-0.1	+0.3	0.0	8)	8)	-	-	PASS (T)	FAIL(T)
VCI	Vinylidenechloride (inhibited)	L	N	N	-	-	-	-	-	-	>100	>100	-	-	FAIL (R)	FAIL(T)
VIS	Vinyl Trichlorosilane	L	N	Y	-	-	SEE HYDROCHLORIC ACID	-	-	-	-	-	-	-	[FAIL](R)	FAIL(T)
XYL	Xylenol (2-4,)	L	N	N	-	-	-	-	-	-	BD	BD	-	-	PASS (R)	FAIL(T-D)
ZEP	Zectran	S	I	N	-	-	-	-	-	-	-	-	-	-	ND	ND
ZAR	Zinc Arsenate	S	I	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)
ZBC	Zinc Bichromate	S	S	N	+0.1	+0.1	+0.2	+1.1	-3.7	-3.7	-	BD	-	-	PASS (T)	PASS (T)

CHRIS CODE	CHEMICAL NAME	WATER		SWATCH TEST						PENETRATION TEST ppm or mg*		SINGLE DECON TEST	MULTIPLE DECON TEST CYCLES			TEST PERFORMANCE RATING			
		S T A T E	R E A C T I V E	POLYCARB		BUTYL		20 hr PHYS. PROPERTY CHANGE (%)	3 hr	20 hr	3 hr		2 hr	POLYCAR- BONATE	BUTYL				
				WEIGHT CHANGE (%)	WEIGHT CHANGE (%)	Tensile	Tear												
																3 hr	20 hr	3 hr	20 hr
ZCL	Zinc Chloride	S	N	-	-	-	-	-	-	-	-	-	-	PASS (R)	FAIL (T)				
ZCR	Zinc Chromate	S	N	-	-	-	-	-	-	-	-	-	-	-	PASS (R)	PASS (R)			
ZCN	Zinc Cyanide	S	N	-	-	-	-	-	-	-	-	-	-	-	ND	ND			
ZPF	Zinc Fluoroborate	L	N	+0.1	-0.2	0.0	-10.0	-6.1	-	-	-	-	-	-	PASS (T)	FAIL (T)			
ZFX	Zinc Fluoride	S	N	+0.1	+0.2	+0.1	+0.5	-3.6	-4.9	-	-	PASS	-	-	PASS (T)	PASS (T)			
ZCL	Zinc Silicofluoride	S	N	+0.1	+0.2	-0.1	+0.3	+2.5	+8.1	-	-	-	-	-	PASS (T)	PASS (T)			
ZPF	Zirconium Potassium Fluoride	S	N	+0.2	0.0	+0.1	+0.3	-1.9	-13.6	-	-	-	-	-	PASS (T)	FAIL (T)			
ZCT	Zirconium Tetrachloride	S	Y	-	-	SEE	HYDROCHLORIC ACID	-	-	-	-	-	-	-	ND	FAIL (T)			

# LEGEND

L Liquid  
S Solid and Soluble  
G Gas  
M Slightly Soluble  
I Insoluble  
- Dash indicates no testing performed  
BD Below Detection  
[ ] Water reactive, pertains to parent compound, literature data  
R Performance rating based on literature review  
T Performance rating based on laboratory tests of parent compound or water reaction product  
T-D Performance rating based on inability to decontaminate  
ND No data